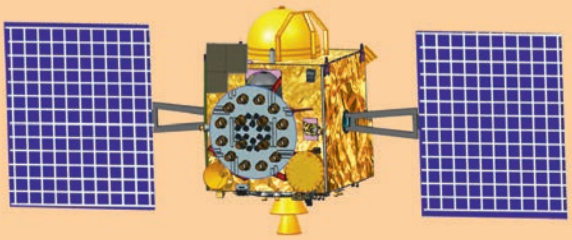


PSLV-C39/IRNSS-1H

PSLV-C39

PSLV-C39 at the Second Launch Pad

The main objective of PSLV-C39, the forty first flight of India's Polar Satellite Launch Vehicle, is the launch of IRNSS-1H, the eighth navigation satellite of India into an elliptical Sub-Geosynchronous Transfer Orbit (Sub-GTO).

PSLV-C39 launch will take place from the Second Launch Pad (SLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. As in the previous seven launches of IRNSS satellites, PSLV-C39 will use 'XL' version of PSLV equipped with six strap-ons, each carrying 12 tons of propellant.

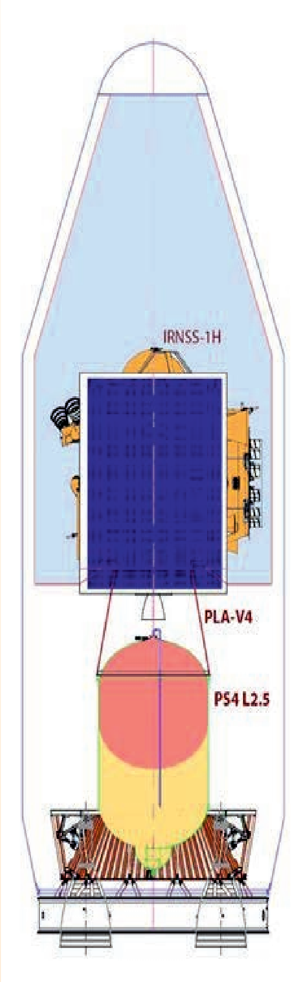
Besides seven IRNSS satellites, PSLV-XL has also launched many other spacecraft including India's Mars Orbiter spacecraft, the multi-wavelength observatory ASTROSAT, Radar Imaging satellite RISAT-1 and the Communication satellite GSAT-12. The launch of 104 satellites during a single mission by PSLV in February 2017 was the most prominent of its recent successes.

PSLV-C39 Vehicle Characteristics	
Vehicle Height	44.4 m
Lift off Mass	321 T

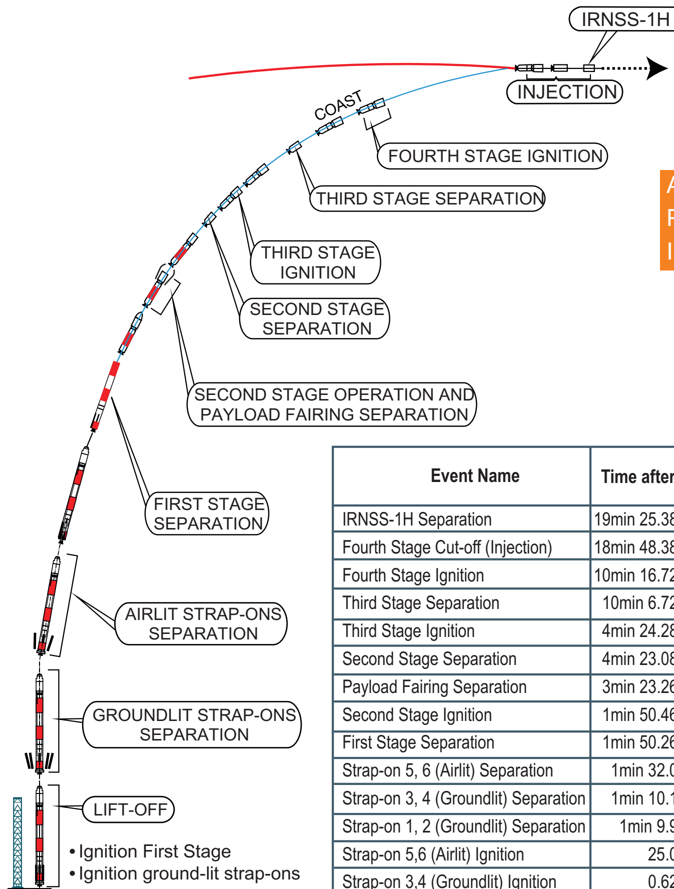
	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.34
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C39



IRNSS-1H in PSLV-C39 envelope



Apogee 20,650 ± 675 km
Perigee 284 ± 5 km
Inclination 19.2 ± 0.2 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1H Separation	19min 25.38 sec	507.555	9597.74
Fourth Stage Cut-off (Injection)	18min 48.38 sec	455.270	9638.79
Fourth Stage Ignition	10min 16.72 sec	187.312	7733.46
Third Stage Separation	10min 6.72 sec	185.537	7735.59
Third Stage Ignition	4min 24.28 sec	135.178	5384.76
Second Stage Separation	4min 23.08 sec	134.966	5385.13
Payload Fairing Separation	3min 23.26 sec	114.951	3705.42
Second Stage Ignition	1min 50.46 sec	55.683	2402.14
First Stage Separation	1min 50.26 sec	55.518	2402.64
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	40.086	2061.57
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	24.113	1470.49
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	23.985	1465.55
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.747	622.47
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.025	451.92
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.025	451.92
First Stage Ignition	0.00	0.025	451.92

PSLV-C39 Typical Flight Profile

Nozzle End Segment of PSLV-C39 core stage being hoisted over the Mobile Launch Pedestal during vehicle integration

PSLV-C39 liquid second stage at the Vehicle Assembly Building during vehicle integration

IRNSS-1H

Hoisting of IRNSS-1H during its integration with conical adapter

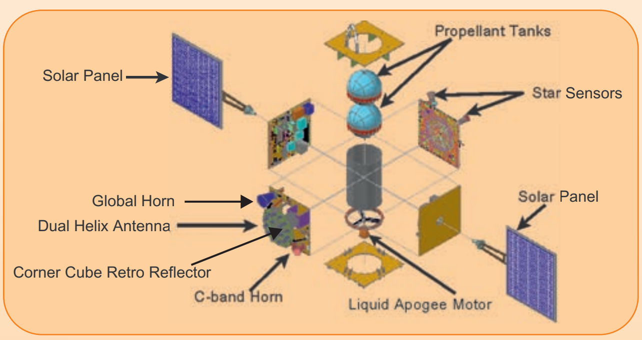
IRNSS-1H will be launched into a sub Geosynchronous Transfer Orbit (sub-GTO) with a 284 km perigee (nearest point to Earth) and 20,650 km apogee (farthest point to Earth) with an inclination of 19.2 deg with respect to the equatorial plane.

After injection into this preliminary orbit, the two solar panels of IRNSS-1H are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres using the Liquid Apogee Motor (LAM) of the satellite, thereby finally placing it in its designated slot in the inclined geosynchronous orbit.

IRNSS-1H Salient features

ORBIT	Geosynchronous with 29 deg inclination, at 55 deg East longitude
LIFT-OFF MASS	1425 kg
DRY MASS	598 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun and Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	10 years

Payloads



IRNSS-1H Disassembled View

Like its other IRNSS predecessors, IRNSS-1H also carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1H will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). Highly accurate Rubidium atomic clocks are part of the navigation payload of the satellite. The ranging payload of IRNSS-1H consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1H also carries Corner Cube Retro Reflectors for laser ranging.

NavIC (Navigation with Indian Constellation)

While IRNSS-1H joins the constellation for providing navigation services, IRNSS-1A will be used for messaging services. IRNSS 1H comes with more flexibility in service and it is compatible with the satellites which are in orbit.

In June 2014, the IRNSS Signal-in-Space Interface Control Document (ICD) for SPS version 1.0 was released in the ISRO website http://irnss.isro.gov.in. The updated ICD version 1.1, with the inclusion of IRNSS 1H satellite information, is now available on the ISRO website.

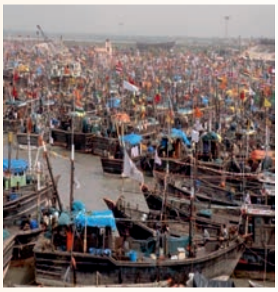
With the operationalisation of seven satellites in 2016, performance of the independent regional navigation satellite system over India was demonstrated for the targeted position accuracy which is better than 20 mtrs over 24 hours of the day.

NavIC ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.

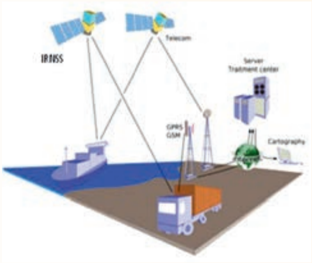
NavIC ground segment is operational 24 x 7. It has a number of Indian Range and Integrity Monitoring Stations, also called IRIMS, which are geographically spread across the country. The ground segment also has IRNSS CDMA Ranging Stations, IRNSS Network Timing Centers, ISRO Navigation Centres and Spacecraft Control Facilities. All of these are interconnected through a robust data communication network.

Important Applications of NavIC

Fisheries: The NavIC has many uses for fishermen going to sea. NavIC system, along with satellite based forecast on fish aggregation areas, helps fishermen to reach the potential fishing zones where they would get better fish catch. Using the messaging capabilities of NavIC, fishermen can receive alerts related to bad weather and high waves. Warning messages are also provided to fishermen when they approach international water boundaries preventing them from crossing inadvertently. All these services are provided through a fishermen app on a smart phone.



Shipping: NavIC helps the merchant ships to navigate to their destination in the ocean routes. It also aids them for search and rescue in disastrous situations using its current location.

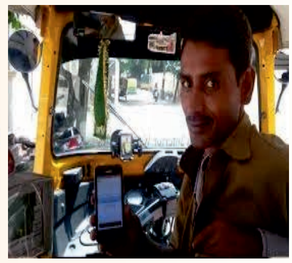


Transport: NavIC, with its position service, supports numerous applications in the road transport sector. It helps the travellers to go from one location to the other and enables transport operators to track their vehicles and goods so that they can manage their operations efficiently. NavIC also helps to monitor the movement of school vans and facilitates better traffic management in cities, towns and highways.

Railways: NavIC is also very useful for railway operations in tracking trains movement, as well as informing the passengers about the time of arrival and departure. It is also useful in alerting the road users at Unmanned Level Crossings to avoid accidents by closely monitoring the approaching trains. The positions of trains are provided to a central monitoring center using communication links.

Resource Management: The position information derived from NavIC helps the Entrepreneurs and the Government Agencies to manage the resources efficiently using Geo-tagging and Geo-fencing techniques. The position of an object is linked with the virtual maps and alert messages are generated when there is a movement of object beyond permissible limits.

Location Based Services: By Linking position information from NavIC with Geo-Informatics Systems where several layers of information are linked on maps and satellite imagery, a host of location based services are offered to the general public. Using such features, one could easily locate a restaurant, shop, college, bus-stop, office, hospital, fuel pump, picnic spot, etc.



Survey and Alignment: Improved position accuracy can be obtained using NavIC signals in combination with Navigation constellations (multi-constellation), using both L5 and S channels. The use of NavIC with differential navigation technique provides much better position accuracies. Such accurate position information helps in applications like land survey, port operations, precision agriculture, road and rail alignments, etc.

Time Synchronised Services: NavIC, with its position and precise timing, significantly contributes in the areas of efficient telecom operations, power grid operations, disaster management, atmospheric studies, etc.

NavIC, when integrated with mobile phones, can bring a major transformation in the delivery of customised applications to the consumer segment.

Designed by: Solus Communication Resources, Bangalore. Aug 2017

Indian Space Research Organisation

Publications and Public Relations
ISRO Headquarters, Antariksh Bhavan,
New BEL Road, Bangalore - 560 231, India.
www.isro.gov.in

IRNSS-1I

PSLV-C41/IRNSS-1I

Indian Space Research Organisation

THE MISSION

43rd flight of Polar Satellite Launch Vehicle (PSLV)

20th flight of PSLV-XL version

32nd Launch of PSLV from the First Launch Pad (FLP) at Satish Dhawan Space Centre SHAR, Sriharikota

Targeted Sub-Geosynchronous Transfer Orbit (Sub-GTO) of PSLV-C41

Perigee	:	284 km
Apogee	:	20,650 km
Inclination	:	19.2 deg
Azimuth	:	104 deg

→

Orbit Raising Manoeuvres using the satellite's onboard propulsion system

ΔV: 1890 metre/sec

→

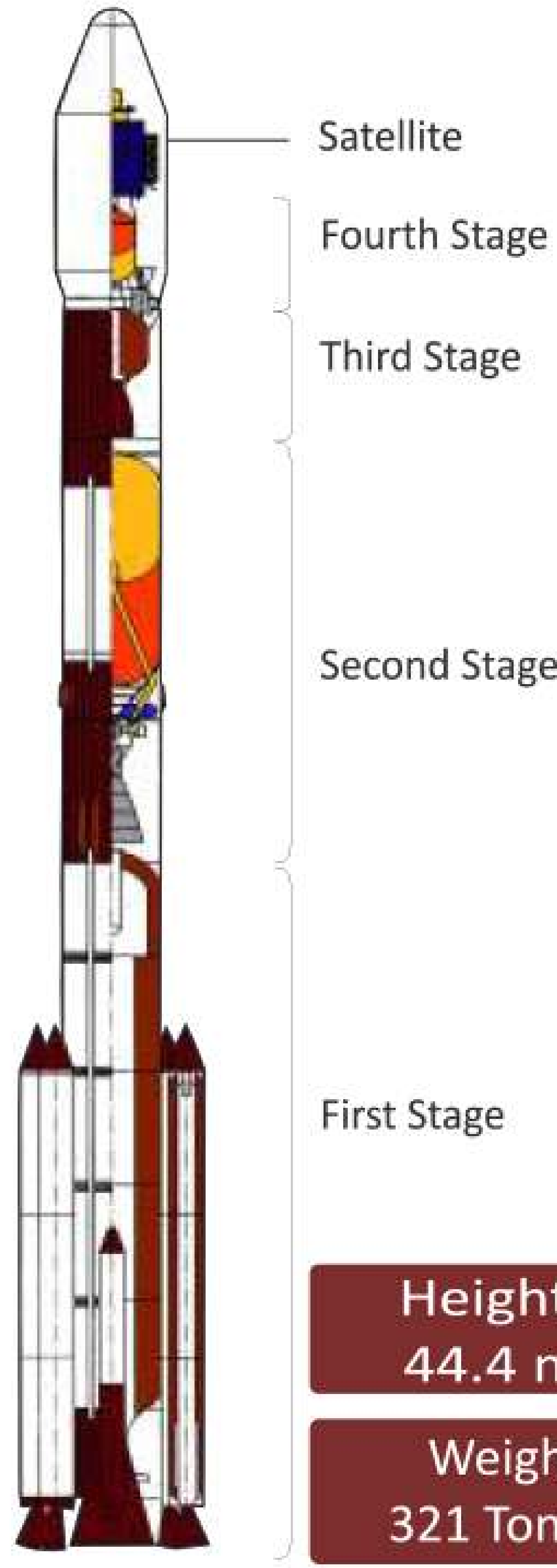
Targeted Orbit of IRNSS-1I

Type	:	Geosynchronous Orbit
Height	:	36,000 km
Inclination	:	29 deg
Longitude	:	55 deg East

THE VEHICLE

PSLV-C41 at a Glance

Parameters	Stages			
	First Stage	Second Stage	Third Stage	Fourth Stage
	Core Stage (PS1) + 6 Strap-on Motors (PSOMs)	PS2	PS3	PS4
Propellant	Composite Solid	Earth Storable Liquid	Composite Solid	Earth Storable Liquid
Propellant Mass (T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Diameter (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.34
Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0
Max. Vacuum Thrust (kN)	4846.9 (Core), 6 x 703.5(Strap-on)	803.78	239.6	2 x 7.33



Height: 44.4 m

Weight: 321 Tonnes

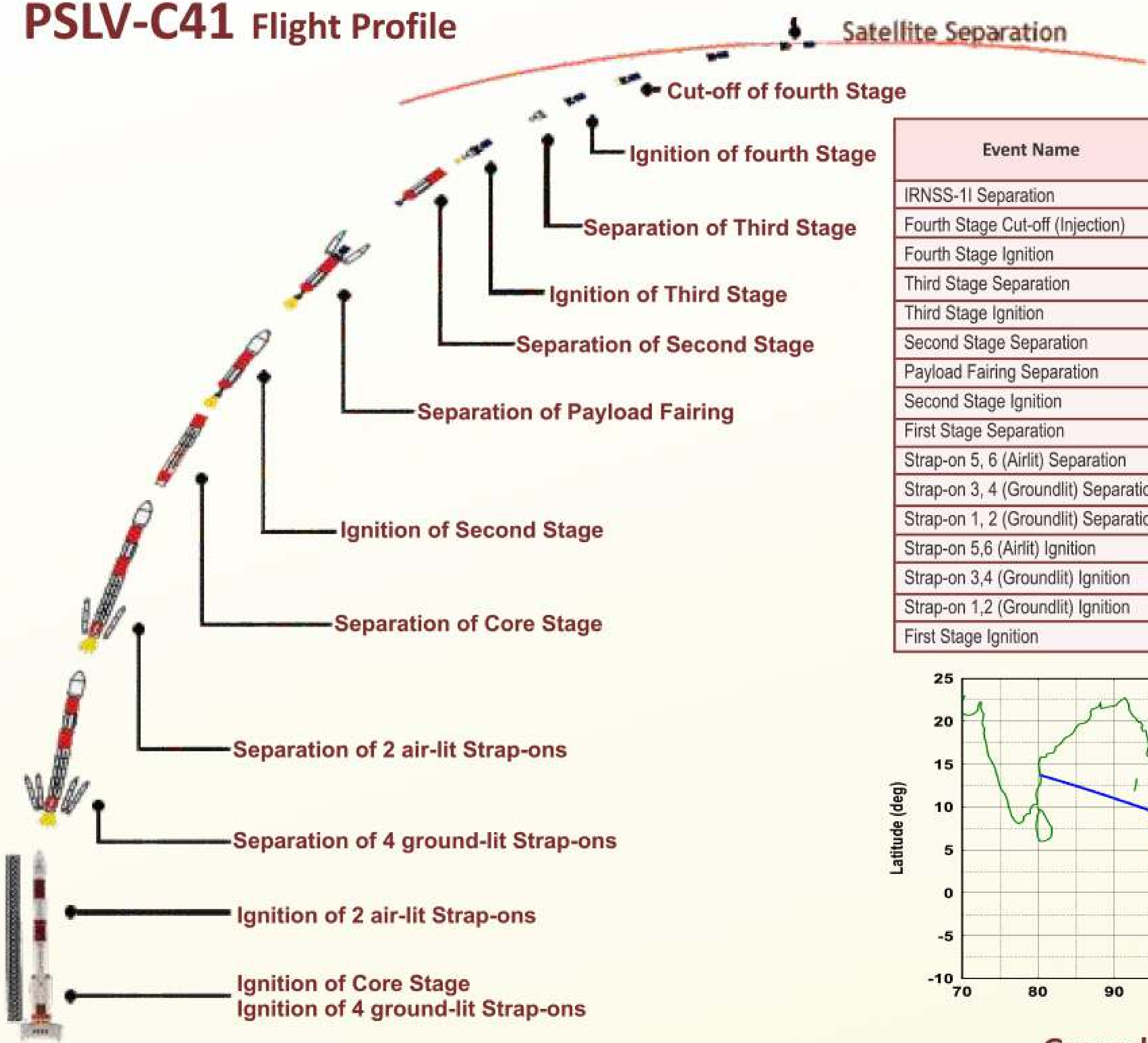
THE SATELLITE

IRNSS-1I during a prelaunch test

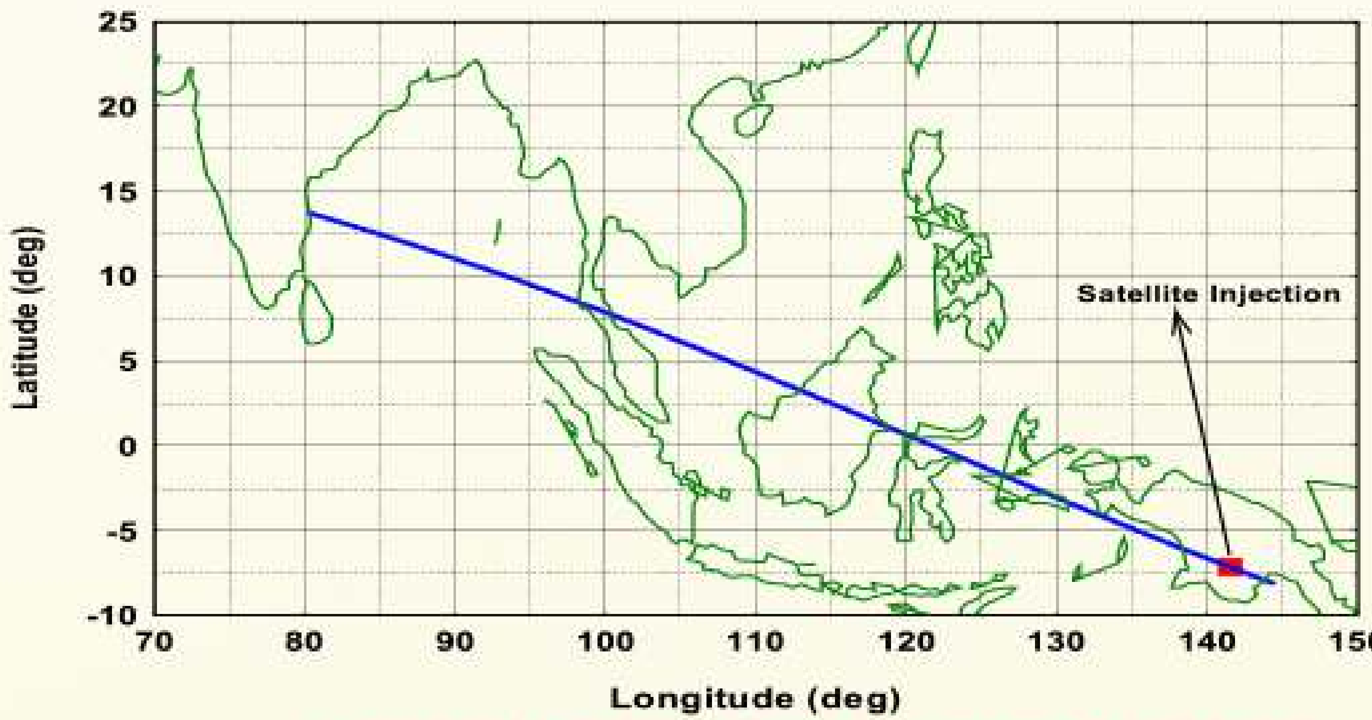
Salient Features of IRNSS 1I

- Transmits Signals for the determination of position, navigation and time
- Lift-Off Weight : 1425 kg
- L5 and S-band Navigation Payload with Rubidium Atomic Clocks
- C-band Ranging Payload
- Corner Cube Retro Reflectors for LASER Ranging
- Overall Size : 1.58m x 1.5m x1.5m
- I-1K Spacecraft Bus
- Power : 1670 W
- Ninth Satellite realised in the Indian Regional Navigation Satellite System (IRNSS) Space segment

PSLV-C41 Flight Profile



Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1I Separation	19 min 19.6 sec	506.708	9597.86
Fourth Stage Cut-off (Injection)	18 min 42.6 sec	454.500	9639.68
Fourth Stage Ignition	10 min 8.72 sec	185.138	7736.57
Third Stage Separation	9 min 58.72 sec	183.301	7738.78
Third Stage Ignition	4 min 24.22 sec	131.771	5395.62
Second Stage Separation	4 min 23.02 sec	131.547	5396.01
Payload Fairing Separation	3 min 23.2 sec	112.883	3711.43
Second Stage Ignition	1min 50.4 sec	55.418	2403.89
First Stage Separation	1min 50.2 sec	55.253	2404.39
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	39.751	2066.62
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	23.766	1469.62
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	23.638	1464.38
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.695	618.95
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0.00	0.024	451.89



Ground Trace of PSLV-C41 Trajectory

Glimpses of Launch Vehicle and Satellite Preparation

PSLV-C41

IRNSS-1I

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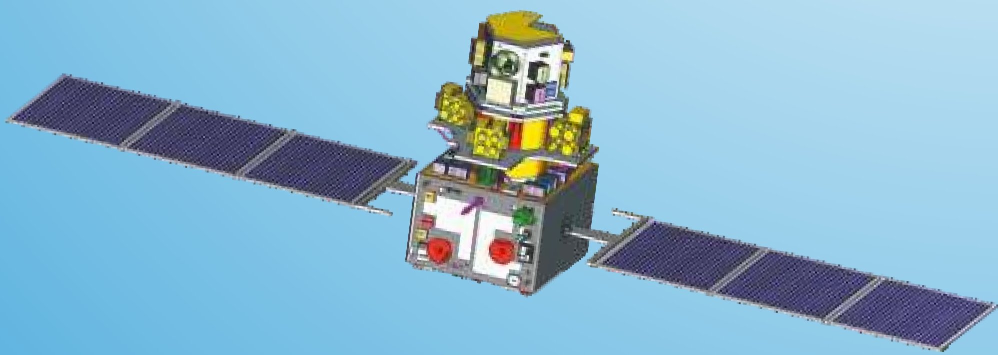


PSLV-C36

RESOURCESAT-2A

PSLV-C36

PSLV-C36 at the First Launch Pad

PSLV-C36 is the thirty eighth flight of ISRO's Polar Satellite Launch Vehicle (PSLV). In this flight, the 'XL' version of PSLV with six solid strap-on motors is used.

PSLV-C36 will place the 1235 kg RESOURCESAT-2A into an 827 km polar Sun Synchronous Orbit (SSO). PSLV-C36 will be launched from the First Launch Pad (FLP) at Satish Dhawan Space Centre SHAR, Sriharikota.

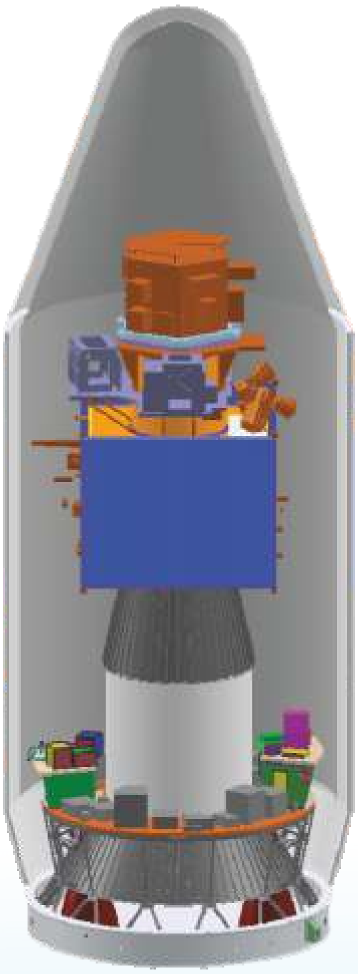
PSLV is the ISRO's versatile launch vehicle for launching multiple satellites in polar SSOs, Low Earth Orbits (LEO) as well as Geosynchronous Transfer Orbit (GTO) and sub GTO. With 36 successful launches, PSLV has emerged as the workhorse launch vehicle of ISRO and is offered for launching satellites for international customers. During 1994-2016 period, PSLV has successfully launched a total of 121 satellites, of which 79 satellites are from abroad and 42 are Indian satellites.

PSLV-C36 at a glance (Vehicle lift-off Mass: 321 tonne Height: 44.4 m)

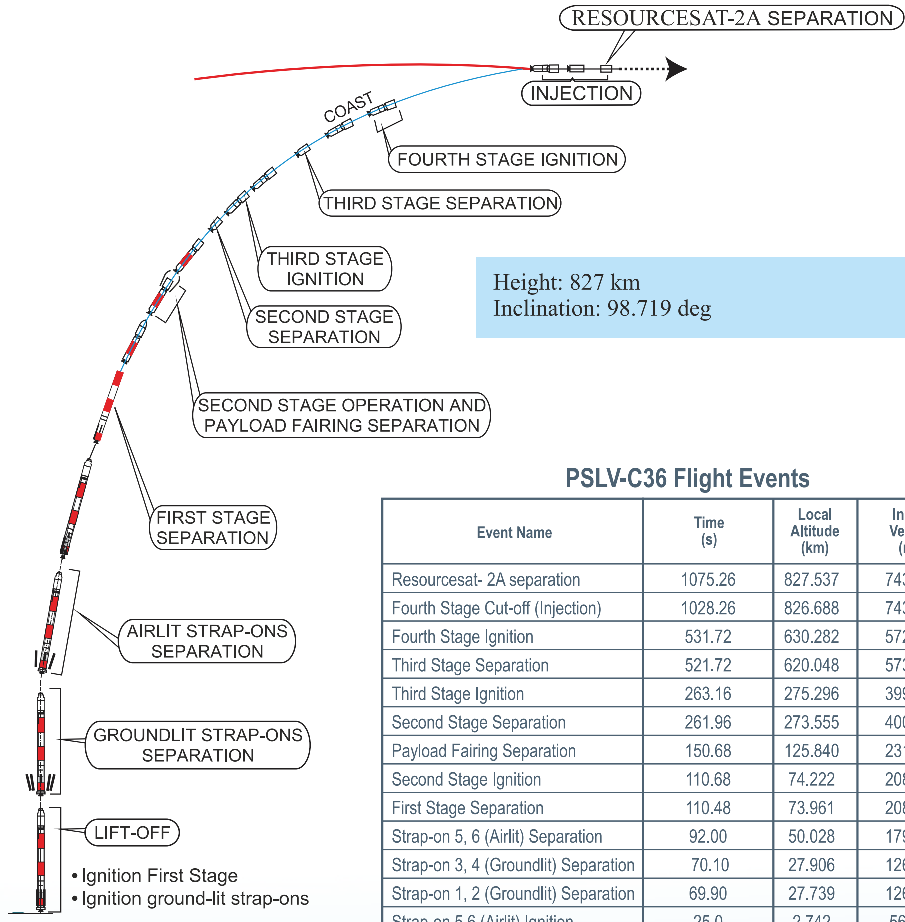
	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	41.7	7.65	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.4
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C36



RESOURCESAT-2A in PSLV-C36 Envelope



Height: 827 km
Inclination: 98.719 deg

PSLV-C36 Flight Events

Event Name	Time (s)	Local Altitude (km)	Inertial Velocity (m/s)
Resourcesat- 2A separation	1075.26	827.537	7439.93
Fourth Stage Cut-off (Injection)	1028.26	826.688	7435.26
Fourth Stage Ignition	531.72	630.282	5724.87
Third Stage Separation	521.72	620.048	5739.37
Third Stage Ignition	263.16	275.296	3999.31
Second Stage Separation	261.96	273.555	4003.24
Payload Fairing Separation	150.68	125.840	2315.30
Second Stage Ignition	110.68	74.222	2085.32
First Stage Separation	110.48	73.961	2086.34
Strap-on 5, 6 (Airlit) Separation	92.00	50.028	1794.43
Strap-on 3, 4 (Groundlit) Separation	70.10	27.906	1265.85
Strap-on 1, 2 (Groundlit) Separation	69.90	27.739	1261.55
Strap-on 5,6 (Airlit) Ignition	25.0	2.742	563.32
Strap-on 3,4 (Groundlit) Ignition	0.62	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42	0.024	451.89
First Stage Ignition	0.00	0.024	451.89

PSLV-C36 Typical Flight Profile

Hoisting of a segment of PSLV-C36 core stage during vehicle integration

PSLV-C36 second stage (liquid) at Stage Processing Facility

RESOURCESAT-2A

RESOURCESAT-2A in clean room before its launch

RESOURCESAT-2A is a Remote Sensing satellite intended for resource monitoring, built by ISRO. RESOURCESAT-2A is a follow on mission to RESOURCESAT-1 and RESOURCESAT-2, launched in 2003 and 2011 respectively. RESOURCESAT-2A is intended to continue the remote sensing data services to global users provided by RESOURCESAT-1 and RESOURCESAT-2

RESOURCESAT-2A carries three payloads which are similar to those of RESOURCESAT-1 and RESOURCESAT-2. They are a high resolution Linear Imaging Self Scanner (LISS-4) camera operating in three spectral bands in the Visible and Near Infrared Region (VNIR) with 5.8 metre spatial resolution and steerable up to ± 26 deg across track to achieve a five day revisit capability. The second payload is the medium resolution LISS-3 camera operating in three-spectral bands in VNIR and one in Short Wave Infrared (SWIR) band with 23.5 metre spatial resolution. The third payload is a coarse resolution Advanced Wide Field Sensor (AWiFS) camera operating in three spectral bands in VNIR and one band in SWIR with 56 metre spatial resolution.

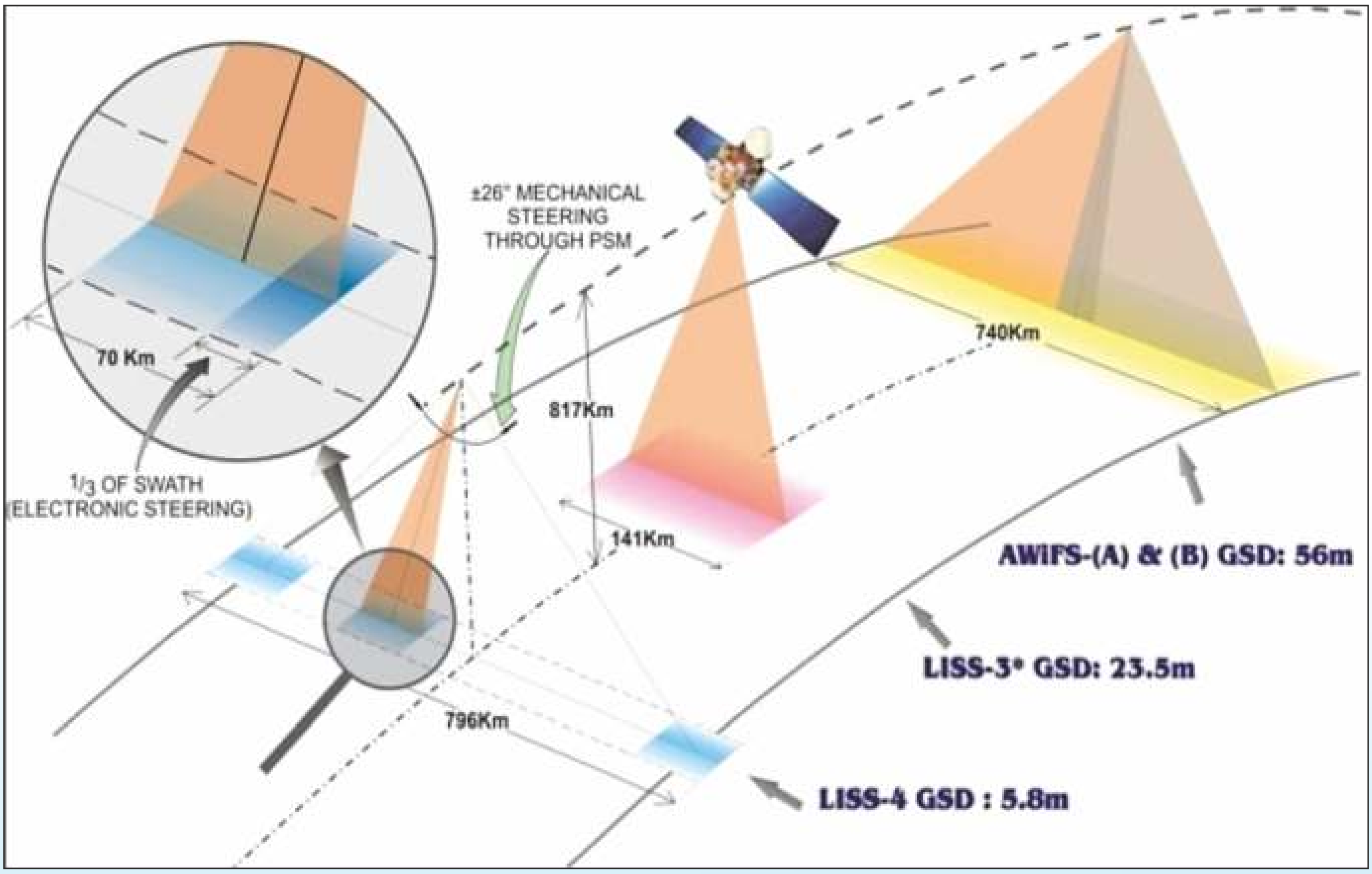
RESOURCESAT-2A carries two Solid State Recorders with a capacity of 200 Giga Bits each to store the images taken by its cameras which can be read out later to ground stations.

Salient Features

Orbit	Circular Polar Sun Synchronous
Orbit height	817 km
Orbit inclination	98.719 deg.
Orbit Period	101.35 min
Number of Orbits per day	14
Local Time of Equator crossing	10.30 AM
Repetivity	24 days
Lift-off Mass	1235 kg
Attitude and Orbit Control	3-axis body stabilised using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters
Power	Solar Array generating 1700 W at End of Life, two 24 AH Ni-Cd batteries
Mission Life	5 years

Three Tier Imaging System of RESOURCESAT-2A

RESOURCESAT series of satellites have a unique 3-Tier imaging system with AWiFS, LISS-3 and LISS-4 sensors. The Advanced Wide Field Sensor (AWIFS) provides images with a resolution of 56 m in 4 bands, has a swath of 740 km and a revisit of 5 days whereas the Linear Imaging Self Scanning Sensor (LISS) -3 provides 23.5 m resolution images in 4 bands with 141 km swath and a repitivity of 24 days. LISS-4 provides 5.8 m resolution images in 3 bands with 70 km swath and has a revisit of 5 days. These multispectral cameras have linear arrays of Charged Coupled Devices (CCDs) as detectors working in push-broom scanning mode.



RESOURCESAT-2A Payload Specifications

Payload	LISS-4	LISS-3	AWiFS
Spatial Resolution (m)	5.8	23.5	56
Swath (km)	70.0 in MX mode and Mono mode	141	740
Spectral Band (microns)	0.52-0.59 0.62-0.68 0.77-0.86	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70
Quantisation (bits)	10	10	12 (VNIR) 14 (SWIR)
Data Rate (MBPS)	105	105	105

INDIAN SATELLITES CARRIED ONBOARD PSLV

Sl. No.	Satellite	Launch Date	Mission
01	IRS-1E*	20.09.1993	PSLV-D1
02	IRS-P2	15.10.1994	PSLV-D2
03	IRS-P3	21.03.1996	PSLV-D3
04	IRS-1D	29.09.1997	PSLV-C1
05	Oceansat(IRS-P4)	26.05.1999	PSLV-C2
06	Technology Experiment Satellite (TES)	22.10.2001	PSLV-C3
07	KALPANA-1(METSAT)	12.09.2002	PSLV-C4
08	Resourcesat-1(IRS-P6)	17.10.2003	PSLV-C5
09	CARTOSAT-1	05.05.2005	PSLV-C6
10	HAMSAT	05.05.2005	PSLV-C6
11	CARTOSAT-2	10.01.2007	PSLV-C7
12	SRE-1	10.01.2007	PSLV-C7
13	CARTOSAT - 2A	28.04.2008	PSLV-C9
14	IMS-1	28.04.2008	PSLV-C9
15	Chandrayaan-1	22.10.2008	PSLV-C11
16	RISAT-2	20.04.2009	PSLV-C12
17	ANUSAT	20.04.2009	PSLV-C12
18	Oceansat-2	23.09.2009	PSLV-C14
19	CARTOSAT-2B	12.07.2010	PSLV-C15
20	STUDSAT	12.07.2010	PSLV-C15
21	RESOURCESAT-2	20.04.2011	PSLV-C16
22	YOUTHSAT	20.04.2011	PSLV-C16
23	GSAT-12	15.07.2011	PSLV-C17
24	Megha-Tropiques	12.10.2011	PSLV-C18
25	SRMSAT	12.10.2011	PSLV-C18
26	Jugnu	12.10.2011	PSLV-C18
27	RISAT-1	26.04.2012	PSLV-C19
28	SARAL	25.02.2013	PSLV-C20
29	IRNSS-1A	01.07.2013	PSLV-C22
30	MOM Spacecraft	05.11.2013	PSLV-C25
31	IRNSS-1B	04.04.2014	PSLV-C24
32	IRNSS-1C	16.10.2014	PSLV-C26
33	IRNSS-1D	28.03.2015	PSLV-C27
34	ASTROSAT	28.09.2015	PSLV-C30
35	IRNSS-1E	20.01.2016	PSLV-C31
36	IRNSS-1F	10.03.2016	PSLV-C32
37	IRNSS-1G	28.04.2016	PSLV-C33
38	Cartosat-2 Series Satellite	22.06.2016	PSLV-C34
39	Satyabhamasat	22.06.2016	PSLV-C34
40	Swayam	22.06.2016	PSLV-C34
41	Scatsat-1	26.09.2016	PSLV-C35
42	Pratham	26.09.2016	PSLV-C35
43	PISAT	26.09.2016	PSLV-C35

* The Satellite could not be placed in orbit.

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Dec. 2016 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bengaluru

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PSLV-C37

CARTOSAT-2 Series Satellite

INS-1A
INS-1B

Dove Satellites (88) [USA]
LEMUR Satellites (8) [USA]
BGUSat [Israel]
Al-Farabi-1 [Kazakhstan]
PEASSS [The Netherlands]
DIDO-2 [Switzerland]
Nayif-1 [UAE]

PSLV-C37

PSLV-C37 at the First Launch Pad

India's Polar Satellite Launch Vehicle, in its thirty ninth flight (PSLV-C37), will launch the 714 kg Cartosat-2 series satellite for earth observation and 103 co-passenger satellites together weighing about 664 kg at lift-off into a 505 km polar Sun Synchronous Orbit (SSO). PSLV-C37 will be launched from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. It will be the sixteenth flight of PSLV in 'XL' configuration (with the use of solid strap-on motors).

The co-passenger satellites comprise 101 International Customer nano satellites, viz., Israel, Kazakhstan, The Netherlands, Switzerland, United Arab Emirates (UAE) and the USA, as well as two nano satellites from India. The total weight of all the satellites carried onboard PSLV-C37 is about 1378 kg.

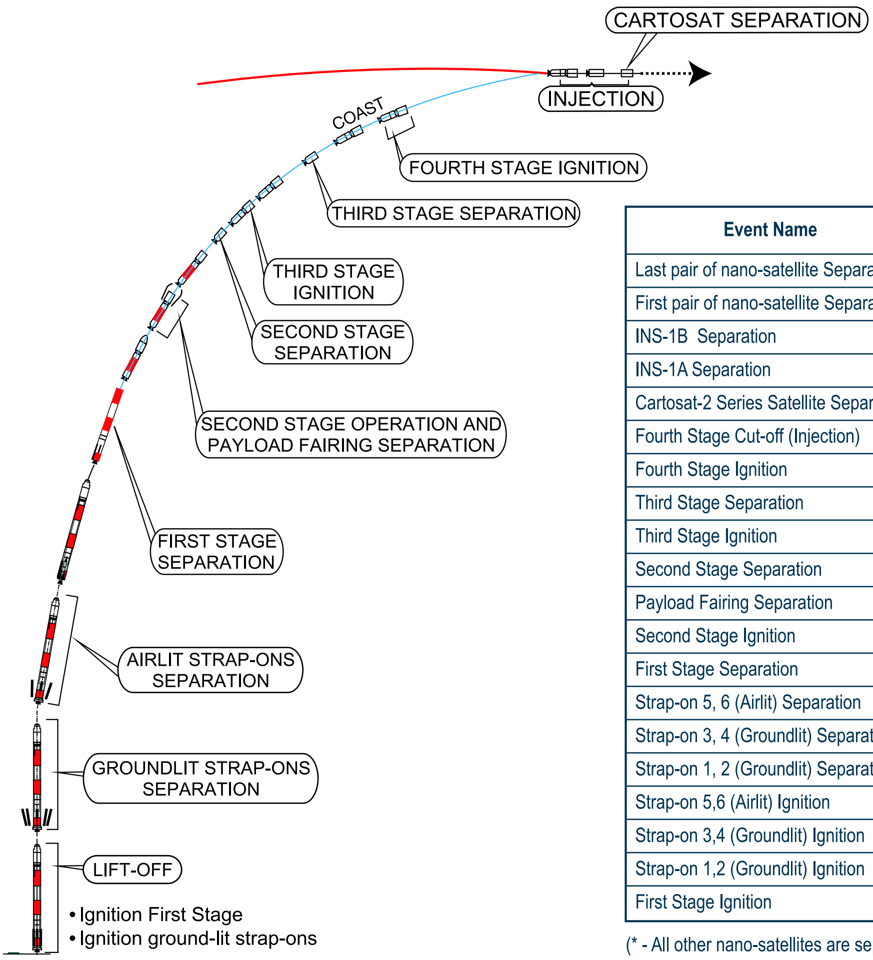
The 101 nano satellites are being launched as part of the commercial arrangement between the International Customer and Antrix Corporation Limited (Antrix), a Government of India company under Department of Space (DOS), the commercial arm of ISRO.

PSLV-C37 at a glance (Vehicle lift-off Mass: 320 tonne   Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C37



Height: 505 km
Inclination: 97.46 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
Last pair of nano-satellite Separation	28 min 42.80 sec	524.075	7602.96
First pair of nano-satellite Separation *	18 min 32.80 sec	511.719	7608.96
INS-1B Separation	17 min 40.30 sec	510.601	7609.41
INS-1A Separation	17 min 39.80 sec	510.590	7609.42
Cartosat-2 Series Satellite Separation	17 min 29.80 sec	510.383	7609.52
Fourth Stage Cut-off (Injection)	16 min 47.80 sec	509.536	7605.59
Fourth Stage Ignition	8 min 22.22 sec	435.029	5824.10
Third Stage Separation	8 min 12.22 sec	428.300	5834.03
Third Stage Ignition	4 min 24.12 sec	220.068	4045.16
Second Stage Separation	4 min 22.92 sec	218.846	4047.94
Payload Fairing Separation	2 min 38.28 sec	116.975	2457.93
Second Stage Ignition	1min 51.08 sec	67.461	2165.16
First Stage Separation	1min 50.88 sec	67.241	2165.97
Strap-on 5, 6 (Airlit) Separation	1 min 32.0 sec	46.295	1858.84
Strap-on 3, 4 (Groundlit) Separation	1 min 10.1 sec	26.611	1324.52
Strap-on 1, 2 (Groundlit) Separation	1 min 9.9 sec	26.457	1319.92
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.761	575.97
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0.00	0.024	451.89

(* - All other nano-satellites are separating in between 18 min 32.80 sec and 28 min 42.80 sec)

PSLV-C37 Typical Flight Profile

Hoisting of Nozzle End Segment of PSLV-C37 core stage during vehicle integration

PSLV-C37 Liquid second Stage at Stage Processing Facility

Primary Satellite

The Cartosat-2 series satellite is the primary satellite carried by PSLV-C37. This satellite is similar to the earlier four satellites of the Cartosat-2 series. After its injection into a 505 km polar Sun Synchronous Orbit by PSLV-C37, the satellite will be brought to operational configuration following which it will begin providing regular remote sensing services using its Panchromatic and Multispectral cameras.

The imagery sent by the satellite will be useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications.

Cartosat-2 series satellite undergoing panel deployment test

Salient features

Satellite mass	714 Kg
Orbit type	Circular polar Sun Synchronous
Orbit height	505 km
Orbit inclination	97.46 degree
Orbit period	94.72 min
Local time of Equator crossing	9:30 am
Power	Solar arrays generating 986 Watts; Two Li-Ion batteries
Attitude control	Reaction wheels, Magnetic torquers and Hydrazine thrusters
Design life	5 years

Co-passenger Satellites

International Customer Satellites

Of the 101 nano satellites from foreign countries, 96 are from USA and the other five are from Israel, Kazakhstan, The Netherlands, Switzerland and UAE.

DOVE (Flock-3P) [USA]

DOVE Flock-3P nano satellites are a fleet of remote sensing satellites that will image the entire Earth every day for commercial, environmental and humanitarian purposes. The Dove satellites are designed, built and operated by Planet Inc., headquartered in San Francisco, USA.

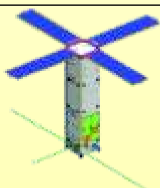
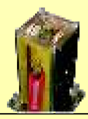
DOVE (Mass: 4.7 kg each)

LEMUR [USA]

LEMUR nano satellites of Spire Global Inc. (San Francisco, CA), USA are meant for providing vessel tracking using Automatic Identification System (AIS), besides carrying out weather measurement using GPS Radio Occultation.

LEMUR (Mass: 4.6 kg each)

Nano satellites from The Netherlands, Switzerland, Israel, Kazakhstan and UAE

Nano Satellite	Country	Built by	Objective
PEASSS (3 kg) 	The Netherlands	European consortium of Partners owned by Innovative Solutions In Space BV	Technology demonstrator nano satellite
DIDO-2 (4.2 kg) 	Switzerland	SpacePharma	Microgravity research nano satellite
BGUSat (4.3 kg) 	Israel	Israeli Aerospace Industries (IAI), in cooperation with the Ben Gurion University	Technology demonstrator for nano satellite avionics systems
Al-Farabi-1 (1.7 kg) 	Kazakhstan	Al-Farabi Kazakh National University (KazNU named after Al-Farabi)	Technology demonstrator nano satellite
Nayif-1 (1.1 kg) 	UAE	Mohammed bin Rashid Space Centre, Dubai	Technology demonstrator nano satellite

Co-passenger Satellites

Indian Satellites

PSLV-C37 carries two ISRO Nano Satellites – INS-1A and INS-1B. ISRO Nano Satellite (INS) is a versatile and modular Nano satellite bus system envisioned for future science and experimental payloads. The INS system is developed as a co-passenger satellite to accompany bigger satellites on PSLV.

The primary objectives of INS system are to:

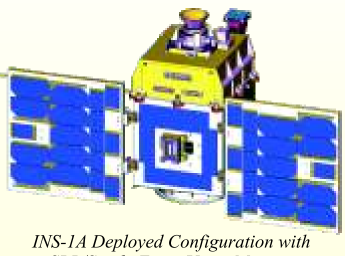
- Design and develop a low cost modular Nano satellite in the weight range of 10 kg capable of carrying payloads up to a weight of 5 kg
- Provide an opportunity for ISRO technology demonstration payloads
- Provide a standard bus for launch on demand services
- Provide an opportunity to carry innovative payloads for Universities / R&D labs

INS-1A and 1B Specifications

INS-1A Lift-off Weight: 8.4 kg Overall Size: 304 x 246 x 364.3 mm^3 (stowed)
304 x 670 x 364.3 mm^3 (deployed)

Payloads:

Surface Bidirectional Reflectance Distribution Function Radiometer (SBR) payload from Space Applications Centre (SAC), Ahmedabad measures the BRDF (Bidirectional Reflectance Distribution Function) of the Earth surface and will take readings of the reflectance of different surface features due to Sun albedo.



INS-1A Deployed Configuration with SBR/Single Event Upset Monitor (SEUM) payload

Single Event Upset Monitor (SEUM) payload from SAC monitors Single Event Upsets occurring due to high energy radiation in the space environment in COTS (Commercial Off The Shelf) components.

Mission Life: 6 months

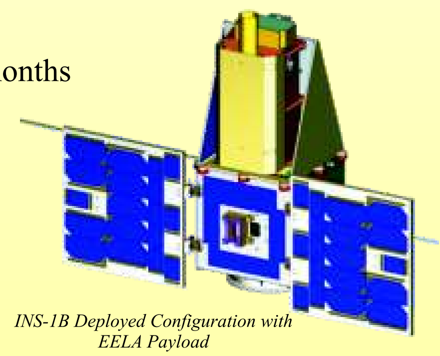
INS-1B Lift-off Weight: 9.7 kg Overall Size: 304 x 246 x 510 mm^3 (stowed)
304 x 670 x 510 mm^3 (deployed)

Payloads:

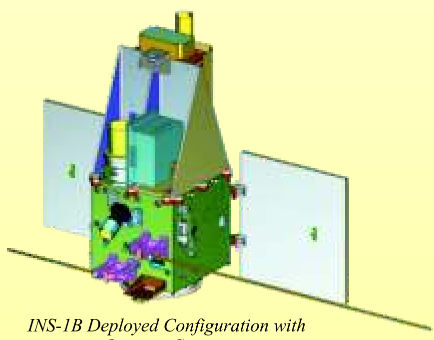
Earth Exosphere Lyman Alpha Analyser (EELA) payload from Laboratory for Electro-Optics Systems (LEOS), Bengaluru Registers terrestrial exospheric line-of-sight neutral atomic hydrogen Lyman Alpha flux. Besides, it will estimate the interplanetary hydrogen Lyman-alpha background flux by means of deep space observations.

Origami Camera payload from SAC is a Remote Sensing Colour camera with a novel lens assembly for optical realisation in a small package. There is scope for its future scalability and utilisation in regular satellites.

Mission Life: 6 months



INS-1B Deployed Configuration with EELA Payload



INS-1B Deployed Configuration with Origami Camera

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Feb. 2017 Design: info@smartworks.in | Printed by: M/s. Aditya Printers, Bangalore.

PSLV-C1/IRS-1 D MISSION

OBJECTIVES

- ***To launch the operational remote sensing satellite IRS - 1D weighing 1200 kg into 817 km polar sunsynchronous orbit.***

- ***To demonstrate first operational mission of PSLV with enhanced payload capability achieved through uprating of propulsion systems and optimising the strapon firing sequence.***

SPECIFICATIONS

Orbit	**- Polar Sunsynchronous Circular (SSPO)**
Altitude	**- 817±35 km.**
Inclination	**- 98.731±0.2 deg.**
Eccentricity	**- 0.001104**
Orbital period	**- 101.35 min.**
Nominal Launch time	**- 10.20 hrs.**
Launch azimuth	**- 140 deg.**

REALISATION

The mission is accomplished through the integrated and coordinated functioning of the following main elements

- **LAUNCH VEHICLE**
- **SPACECRAFT**
- **LAUNCH RANGE FACILITIES**
- **TELEMETRY, TELECOMMAND AND TRACKING SYSTEMS**

All the ISRO centres are actively engaged in the realisation of the mission

- **Vikram Sarabhai Space Centre, Thiruvananthapuram**

Lead centre with the major responsibility of Launch Vehicle design, project management, mission planning , Integration & checkout.

- **Liquid Propulsion Systems Centre, Valiamala, Mahendragiri and Bangalore**

Design, realisation and testing of liquid propulsion systems including control powerplants

- **ISRO Satellite Centre, Bangalore**

Design, realisation, testing and integration of satellite systems

- **Shriharikota Range**

Vehicle assembly and launch operation, manufacturing and testing of large solid propellant boosters

- **Space Applications Centre, Ahmedabad**

Realisation of payloads for the satellite

- **ISRO Telemetry Tracking Centre, Bangalore, SHAR & Thiruvananthapuram**

Provide telemetry and tracking support for the mission

- **ISRO Inertial Systems Unit, Thiruvananthapuram**

Realisation of Inertial Navigation Systems for Launch Vehicle and Satellite

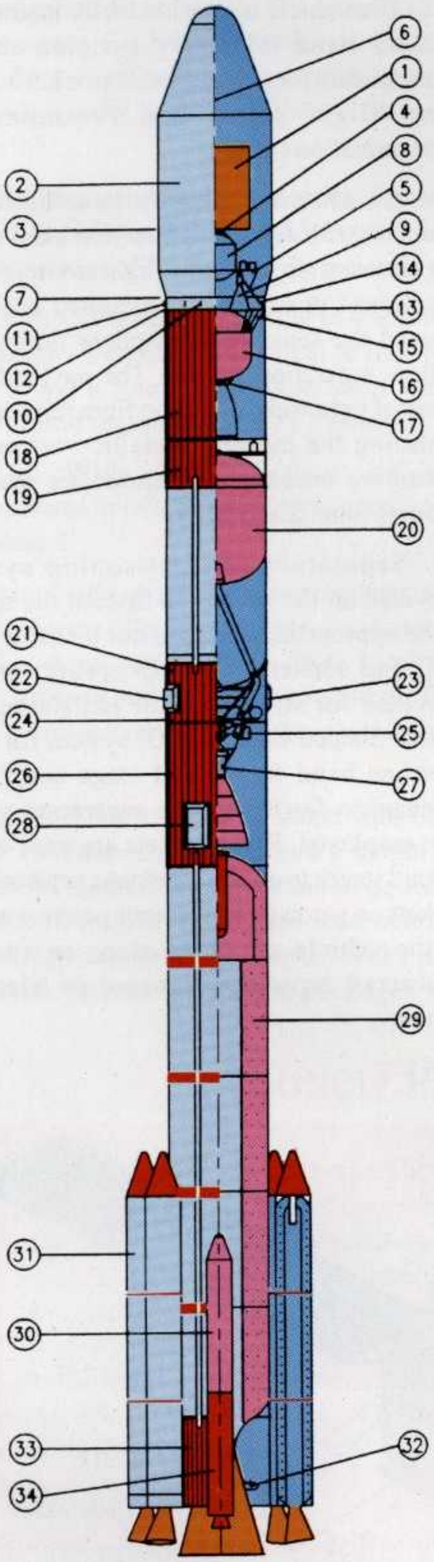
In addition to the ISRO Centres a large number of major and minor industries also contribute in the realisation of the vehicle and spacecraft systems

VEHICLE

Vehicle height	-	**44.4 m**
Lift off mass	-	**294 t**
Maximum vehicle diameter at heatshield	-	**3.2 m**
Vehicle envelope diameter at base	-	**5.1 m**

In this fourth flight, the Polar Satellite Launch Vehicle, PSLV - C1, is deployed on its first operational mission of lauching Indian remote sensing satellite IRS-1D into sunsynchronous polar orbit. The launching of this satellite demonstrates the country's total self reliance in this vital application area. The payload capability of the PSLV has been enhanced to 1200kg in this mission to meet the requirement of the operational IRS-1D satellite. This has been achieved mainly through increase in the first and second stage propellant loading, altering the sequence of ignition of the strapons and reduction in inert mass of the fourth stage.

The PSLV with an overall height of 44.4 metres and lift off mass of 294 tonnes is configured as a four stage vehicle with alternate solid and liquid propulsion modules. The first stage motor of PSLV-C1 carries 138t, of solid propellant and measures 2.8m in diameter. The motor case is made of indigenously produced high strength steel. The first stage thrust is augmented by six 1.0m diameter solid propellant strapon motors. Four of these strapon motors, are ignited on the ground and the remaining two in flight considering the requirement of maximising payload. The solid booster uses indigenously produced propellant, a combination of Hydroxyl Terminated polybutadiene (HTPB) fuel and Ammonium Perchlorate Oxidiser. The second stage, uses the indigenously developed Vikas engine, and carries over 40t of liquid propellant - Unsymmetrical Dimethyl Hydrazine as the fuel and N2O4 as the oxidiser. The third stage uses kevlar epoxy motor case and carries 7t of solid propellant (HTPB). It has a contoured and submerged nozzle. The fourth stage uses 2t of liquid propellant - MON



1. PAYLOAD
2. HEATSHIELD
3. PAYLOAD SEPARATION PLANE
4. PAYLOAD ADAPTOR
5. EQUIPMENT BAY
6. HEATSHIELD SEPARATION PLANE VERTICAL
7. HEATSHIELD SEPARATION PLANE HORIZONTAL
8. FOURTH STAGE PROPELLANT TANK
9. FOURTH STAGE ENGINE (2)
10. ANTENNAE
11. REACTION CONTROL THRUSTER (6)
12. THIRD STAGE SEPARATION PLANE
13. SECOND STAGE SEPARATION PLANE
14. INTER STAGE 3/4
15. THIRD STAGE ADAPTOR
16. THIRD STAGE MOTOR
17. FLEX NOZZLE CONTROL SYSTEM
18. INTER STAGE 2/3U
19. INTER STAGE 2/3L
20. SECOND STAGE PROPELLANT TANK
21. INTER STAGE 1/2U
22. RETRO ROCKET (4)
23. ULLAGE ROCKET (4)
24. FIRST STAGE SEPARATION PLANE
25. GIMBAL CONTROL SYSTEM
26. INTER STAGE 1/2L
27. SECOND STAGE ENGINE
28. RETRO ROCKET (8)
29. FIRST STAGE MOTOR
30. SITVC INJECTANT TANK (2)
31. STRAP-ON MOTOR (6)
32. SITVC SYSTEM
33. BASESHROUD
34. ROLL CONTROL ENGINE (2)

POLAR SATELLITE LAUNCH VEHICLE

and MMH and has two high performace engines of 7kN thrust.

PSLV is guided and controlled in all the three axes from lift - off to spacecraft injection by the Navigation, Guidance and Control system (NGC) housed in the equipment bay. The closed loop guidance scheme resident in the on-board computer ensures the required accuracy in the injection conditions. The three axes attitude stabilisation of the vehicle is achieved by the autonomous control systems provided in each stage.

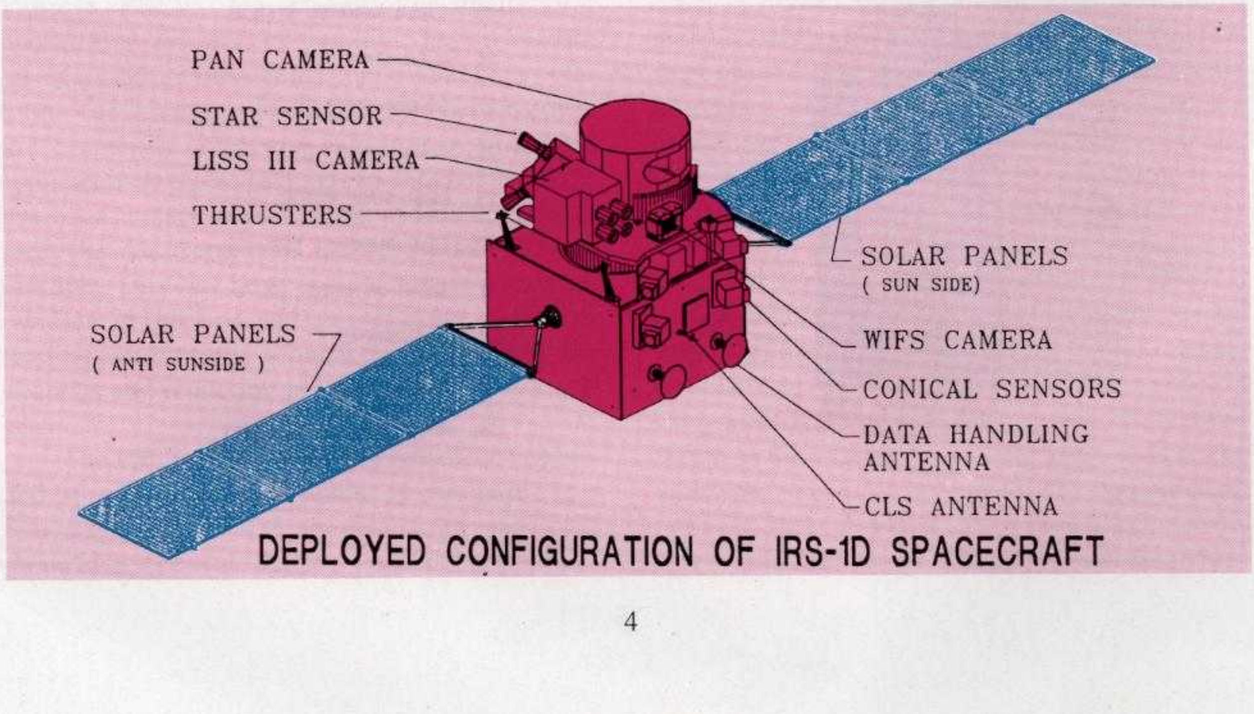
The first stage is provided with Secondary Injection Thrust Vector Control (SITVC) for pitch and yaw control . Two Swivellable Roll Control Thrusters (RCT) are used for roll control. After the first stage burnout, and before the second stage control takes over, RCT engines are used for yaw and roll control and a set of four Reaction Control Thrusters (RCT) are used for pitch control. Second stage has Engine Gimbal Control (EGC) for pitch and yaw and Hot Gas Reaction Control system (HRCS) for roll control. The third stage has Flex Nozzle Control (FNC) for the pitch and yaw control during thrust phase. The fourth stage is controlled during thrust phase by gimballing its two engines for pitch, yaw and roll. A Reaction Control System (RCS) with six thrusters is provided on fourth stage for coast phase control of both third and fourth stages.

The vehicle is provided with instrumentation, PCM-S band telemetry systems and C-band transponders for performance monitoring, tracking, range/flight safety and Preliminary Orbit Determination (POD).

An aluminium alloy heatshield of 3.2m diameter with acoustic protection blankets protects the spacecraft from hostile flight environment during the ascend phase and is separated and jettisoned beyond the sensible atmosphere through a linear bellow separation system. The payload adaptor is made of light weight Carbon fibre reinforced plastic replacing the existing metallic version . All the remaining interstage structures are made of high strength aluminium alloy.

Separation and jettisoning systems are provided on the vehicle to discard the spent stages at the appropriate time without boundary collision. Ball and socket joint with spring thrusters are provided for strapon motor jettisoning. Flexible Linear Shaped Cord (FLSC) system for first stage, Merman band for second stage and 'Ball lock' mechanism for third stage separation systems are also employed. Retro rockets are used on first and second stages to ensure safe stage separation. Ullåge rockets on second stage ensures positive acceleration of the vehicle at second stage engine ignition. Spacecraft separation is based on Merman band system.

SPACECRAFT



DEPLOYED CONFIGURATION OF IRS-1D SPACECRAFT

The indigenously built IRS-1D spacecraft is the in orbit spare for IRS-1C which is already in service. The satellite weighing 1200 kg will have payloads similar to that of IRS-1C as listed below.

i) A high resolution Panchromatic Camera (PAN) with a resolution of 5.6 meters and additional off nadir viewing capability.

ii) LISS - 3 Cameras operating in 4 spectral bands - 3 bands are identical to IRS-1A/1B and a fourth band is in short wave infrared region of 1550 - 1750 nm.

iii) The Wide Field Sensor (WiFS) operates in two bands namely band 3 and band 4.

The spacecraft consists of a mainframe and a payload platform. The mainframe consists of mechanical system, power, TTC, Data handling system and Attitude and orbit control system. The payload platform accommodates the paylods and some sensors.

The satellite has a cuboidal shape with base dimensions 1650mm x 1550mm and a height of 2300mm in the stowed configuration. The main platform is built around a stiffened load bearing cylinder with honeycomb horizontal decks and vertical panels. While subsystem packages are mounted on the inside of the honeycomb panels the payloads are fixed on a special top deck thermally isolated from the main body through a CFRP cylinder. The interface with the vehicle is through a merman band joint of 937mm diameter. The interface ring is rivetted to the load bearing stiffened cylinder.

Two deployable suntracking solar arrays on each side with 3 panels each of 1.1m x 1.46m generating 813 w of power cater to the power requirements while two 21 AH batteries take care of the eclipse periods. Telemetry, Tracking and Command system is configured around S-band coherent transponder. Telemetry system monitors all the housekeeping data and the data can be transmitted both in real time and playback mode simultaneously in conjunction with an onboard tape recorder.

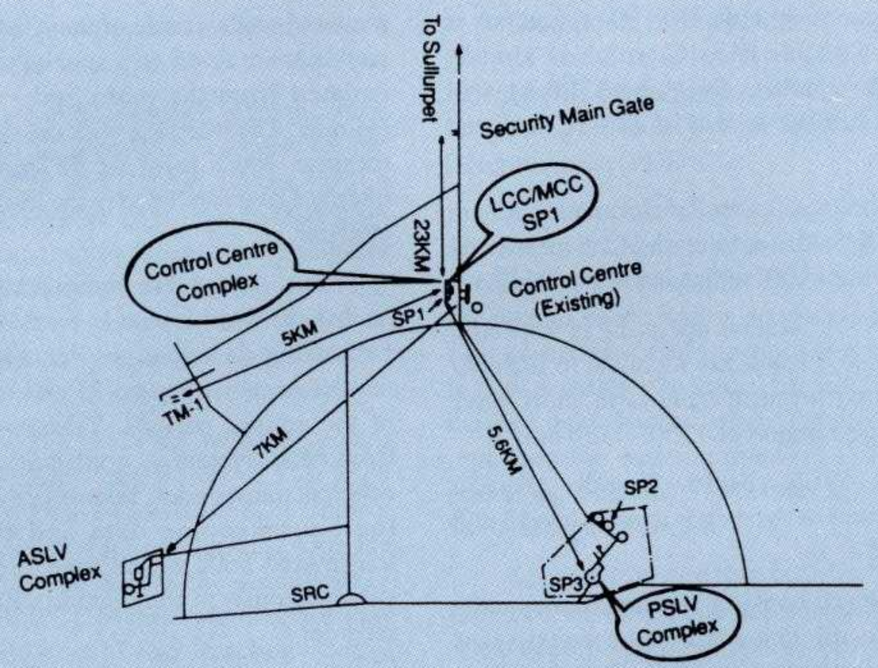
The Attitude and Orbit Control System ensures the 3 axis attitude holding and orbit control of the satellite. The AOCS is configured around 4 reaction wheels and magnetic torquers for momentum dumping backed up by monopropellant hydrazine thrusters. The satellite is also capable of orbital velocity correction upto 40m/s by using the 11 Newton thruster.

LAUNCH RANGE FACILITIES

The final vehicle and spacecraft preparations, integration, checkout and the lunching of the vehicle are carried out at Launch Range facilities at Sriharikota Range (SHAR). The SHAR complex located at 80 km north east of Chennai (lat.13.73, long.80.24) is ideally located at the east coast of India. It has all the required facilities for the launch of space vehicles both in low earth as well as polar orbits. The main elements of the PSLV launch complex are the following.

* Mobile Service Tower (MST), Umbilical Tower (UT) & Launch pedestal
* Solid Motor Preparation Facility
* Subsystem preparation facility for all interstages, PS2, heatshield and spacecraft
* Liquid propellant storage and transfer facility
* Hardware storage facility for interstages
* Launch Control Centre (LCC) & Mission Control Centre (MCC)
* Range Instrumentation and support facility

The vehicle is vertically integrated over the launch pedestal which is located above the jet



LAUNCH RANGE FACILITIES

deflector and the two exhaust ducts enable smooth flow of the exhaust gases. The umbilical tower provides interface structure through which all the required fluid servicing lines and electrical checkout lines are attached to the vehicle and disconnected at lift-off. At the time of vehicle integration, the 75m tall Mobile Service Tower is positioned around the launch pedestal and the Umbilical Tower and provides the access and protective enclosure for the vehicle integration. It also provides handling systems and clean environment for the vehicle and satellite assembly. The tower can be moved on a rail system to a safe distance of 100m from the vehicle before launch.

Located 5km away from the launch pad, the LCC has facilities for the remote checkout and launch of the vehicle. The LCC houses all the vehicle control consoles, filling consoles as well as checkout and automatic launch systems. It is connected to the launch pad through fibre optic data links and the data is fed in real time to computers as well as specialists' consoles in the appropriate form.

The Mission Control Centre located adjacent to LCC has consoles for the mission executives who authorise the launch based on readiness of all the systems. The vehicle performance is displayed in large display boards graphically in real time. The range safety console is manned by the Range Safety Officer who is authorised to terminate the vehicle in case of a vehicle malfunction which can pose danger to men and materials on ground.

The major Range Instrumentation and support Facilities are -

- Tracking systems like Precision 'C' band and 'S' band radars
- Telecommand System
- Support System like Intercommunication, CCTV System, Data Links, Range Timing System, Real Time Systems and Specialist display System; and
- Metereology and Technical photography

TELEMETRY, TELECOMMAND AND TRACKING SYSTEMS

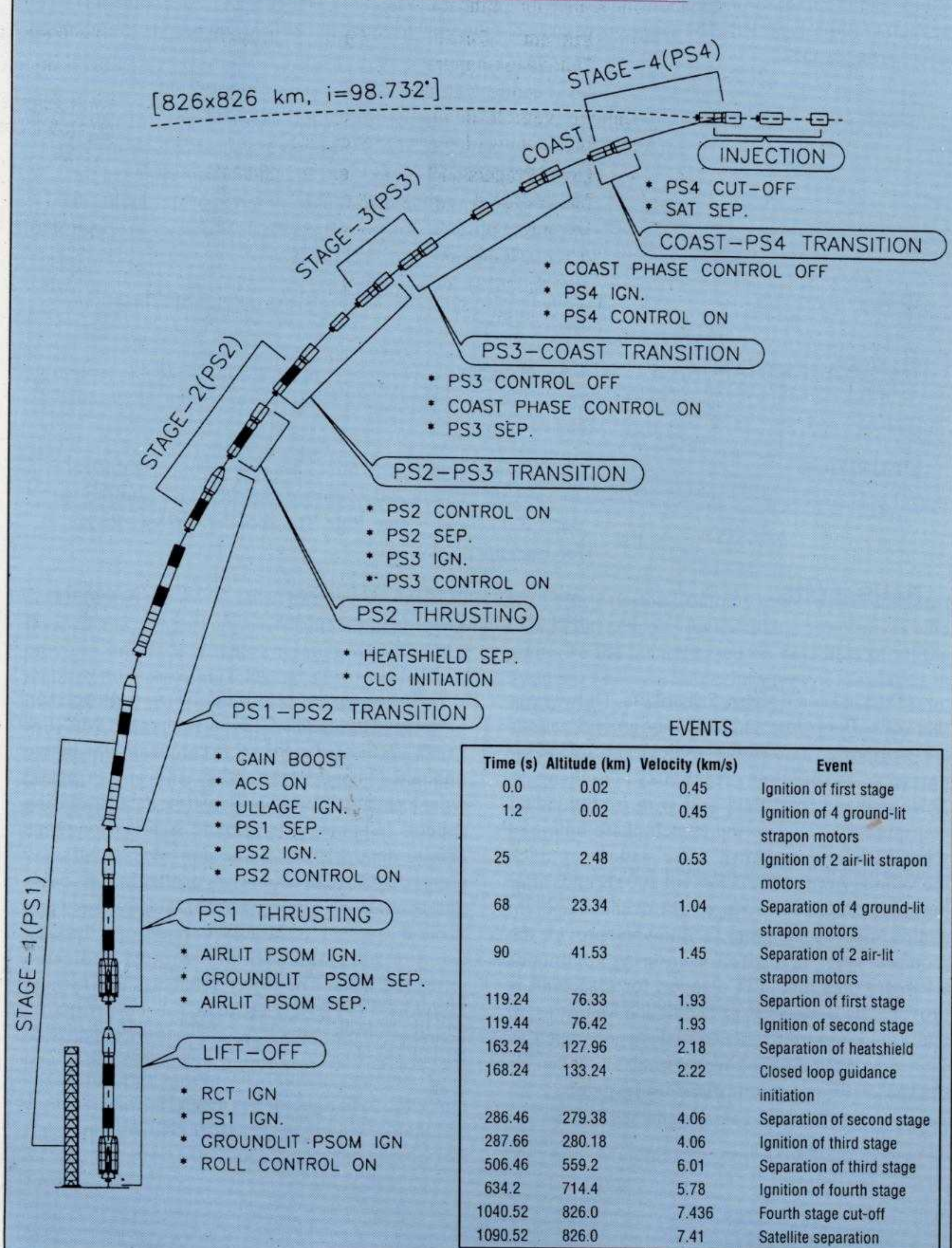
Ground systems and Ground stations play a very important role in confirmation of the mission, ensuring Range and flight safety and enabling post flight data analysis. Telemetry Tracking and Telecommand (TTC) support to PSLV is provided by a network of ground stations which track the vehicle and acquire the telemetry data during launch.

SHAR - I	Acquisition of Telemetry carriers TMI and TM2 of vehicle, data recording, prepocessing and transmission to mission computer for Range Safety and Specialist Display in real time. Ranging with satellite transponder. Acquisition of satellite data recording preprocessing and transmission to Satellite Control Centre, Bangalore.
SHAR - II	Launch base total redundant station doing same function as SHAR 1
THIRUVANANTHAPURAM	Immediate Range Station Serving as space diversity reception to ensure continuous data even during flame attenuation periods.
MAURITIUS	Down Range Station with three carrier reception capability of all Satellite carriers and ranging capability with satellite 'S' Band Range and Range Rate Transponder. PCMC Radar for tracking the vehicle.
BANGALORE	Additional backup for Vehicle Telemetry and TTC Station for IRS-1D support during initial phase.

During launch phase, Sriharikota, Thiruvananthapuram, Bangalore and Mauritius ground stations are configured to receive vehicle and telemetry carriers. SHAR has Telemetry Tracking & Telecommand facilities and with its redundant configuration, cater to the launch phase upto 680 seconds. Mauritius Down range station can track the vehicle from 656 seconds till 200 seconds after burnout of the fourth stage. Thiruvananthapuram station has only telemetry facilities and provide the required space diversity for ensuring continuous telemetry data link. TTC support for spacecraft is provided by Bangalore, Lucknow and Mauritius. In addition, support from external stations such as Bearslake, Pokerflat and Welheim are also taken for the spacecraft operations in the initial phase.

Tracking is provided by two Precision Coherent Monopulse C-Band Radars (PCMC-1 & PCMC-2) located at SHAR in conjunction with two onboard C-band transponders and one PCMC-3 radar located at Mauritius. Real time data processing support is provided by ground stations for range safety, data display at the consoles at Mission Control Centre and for preliminary orbit determination. The data transmission between ground stations is largely carried out through satellite links and partially through dedicated terrestrial links. The ISRO Telemetry & Tracking Network (ISTRAC) ensures the co-ordinated operation of the various ground stations and provide the necessary services during the mission in this vital area.

PSLV-C1 FLIGHT PROFILE



EVENTS

Time (s)	Altitude (km)	Velocity (km/s)	Event
0.0	0.02	0.45	Ignition of first stage
1.2	0.02	0.45	Ignition of 4 ground-lit strapon motors
25	2.48	0.53	Ignition of 2 air-lit strapon motors
68	23.34	1.04	Separation of 4 ground-lit strapon motors
90	41.53	1.45	Separation of 2 air-lit strapon motors
119.24	76.33	1.93	Separtion of first stage
119.44	76.42	1.93	Ignition of second stage
163.24	127.96	2.18	Separation of heatshield
168.24	133.24	2.22	Closed loop guidance initiation
286.46	279.38	4.06	Separation of second stage
287.66	280.18	4.06	Ignition of third stage
506.46	559.2	6.01	Separation of third stage
634.2	714.4	5.78	Ignition of fourth stage
1040.52	826.0	7.436	Fourth stage cut-off
1090.52	826.0	7.41	Satellite separation

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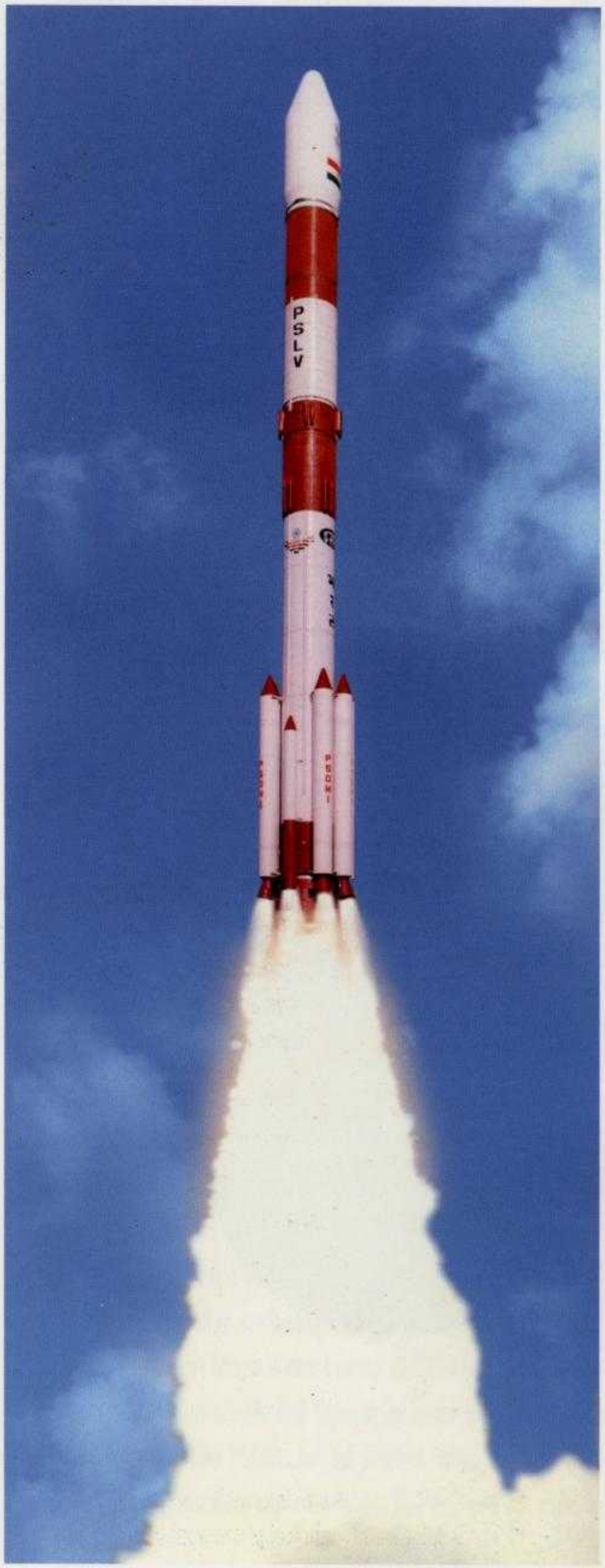
Digitised Typesetting and Printing at SB Press, College Lane, Trivandrum -1.

PSLV-C2 MISSION



INTRODUCTION

The C2 mission is the second operational flight of PSLV to deploy the Indian Remote Sensing Satellite IRS-P4 which is dedicated for ocean study. To exploit the spare payload capacity in this flight, two auxiliary satellites are also carried onboard in piggy back mode. These are injected into the same orbit as the primary satellite soon after the primary satellite separation. Special interface provisions are created on the vehicle to mount these satellites and separate them at the appropriate time.

MISSION OBJECTIVES

- Launch the Indian Remote Sensing Satellite-OCEANSAT-1 (IRS-P4) weighing 1050 kg into sunsynchronous polar orbit.

- Deliver the two auxiliary experimental satellites 110kg KITSAT-3 from South Korea and 45kg DLR-TUBSAT from Germany into the same orbit.

MISSION SPECIFICATIONS

The mission specifications are tailored to meet IRS-P4 requirements

Orbit	- Sun synchronous Polar orbit (SSPO)
Altitude	- 727 ± 35km
Inclination	- 98.286 ± 0.2deg.
Orbital Period	- 99.310 min
Launch time	- Between 11-40 and 11-50 Hrs. IST
Launch Azimuth	- 140 deg.

CONTRIBUTING ISRO ENTITIES

PSLV-C2 / IRS-P4 MISSION

Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram
Launch vehicle design, realisation of subsystems, mission planning, Project management, Integration and checkout

Liquid Propulsion Systems Centre (LPSC) Valiamala, Mahendragiri and Bangalore
Design, Realisation and testing of Liquid propulsion systems and control power plants for launcher and spacecraft

Launch Vehicle Programme Office (LVPO), ISRO Headquarters, Bangalore
Launch Vehicle Programme Planning & Customer Coordination

National Remote Sensing Agency (NRSA), Hyderabad
Generation & Marketing of Remote Sensing Products

ISRO Satellite Centre (ISAC), Bangalore
Design, Realisation, Intergration and testing of IRS-P4 satellite

Sriharikota Range (SHAR) Sriharikota, Andhrapradesh
Manufacture and testing of large solid propellant boosters. Vehicle assembly and launch operation, range instrumentation and safety.

Space Applications Centre (SAC), Ahmedabad
Realisation of satellite payloads

ISRO Telemetry Tracking and Command Network (ISTRAC) Bangalore, SHAR and Thiruvananthapuram
Telemetry and tracking support for the mission

ISRO Inertial Systems Unit (IISU) Thiruvananthapuram
Realisation of Inertial Navigation Systems for Launch vehicle and Satellite

LAUNCH VEHICLE

The Polar Satellite Launch Vehicle entered its operational phase with the successful launching of IRS-ID into 817 km SSPO through PSLV-C1. The vehicle configuration for PSLV-C2 is essentially same as PSLV-C1. The four stage Polar Satellite Launch Vehicle (PSLV) is developed primarily for deploying remote sensing satellites of 1000kg class in polar sun synchronous orbits. It is powered by solid propellant first and third stages and liquid propellant second and fourth stages. A 2.8m diameter core motor and six 1.0 m diameter strapon motors (PSOMs) constitute the first stage. Four of the strapons are ignited on ground while the remaining two are ignited in flight considering the requirement of maximising payload and limiting the vehicle loads during flight. The core motor case is made of high strength steel and carries 138t solid propellant. The second stage carries 40t of propellant(Unsymmetrical Dimethyl Hydrazine & Nitrogen tetroxide) in an aluminium tank with a common bulkhead and powered by the 'Vikas' engine. The third stage using composite motor case carries 7.3t of solid propellant. It has a contoured and submerged nozzle. The fourth stage uses 2t of propellants (Mixed oxides of Nitrogen & Monomethyl hydrazine) and has two high performance pressurefed engines.

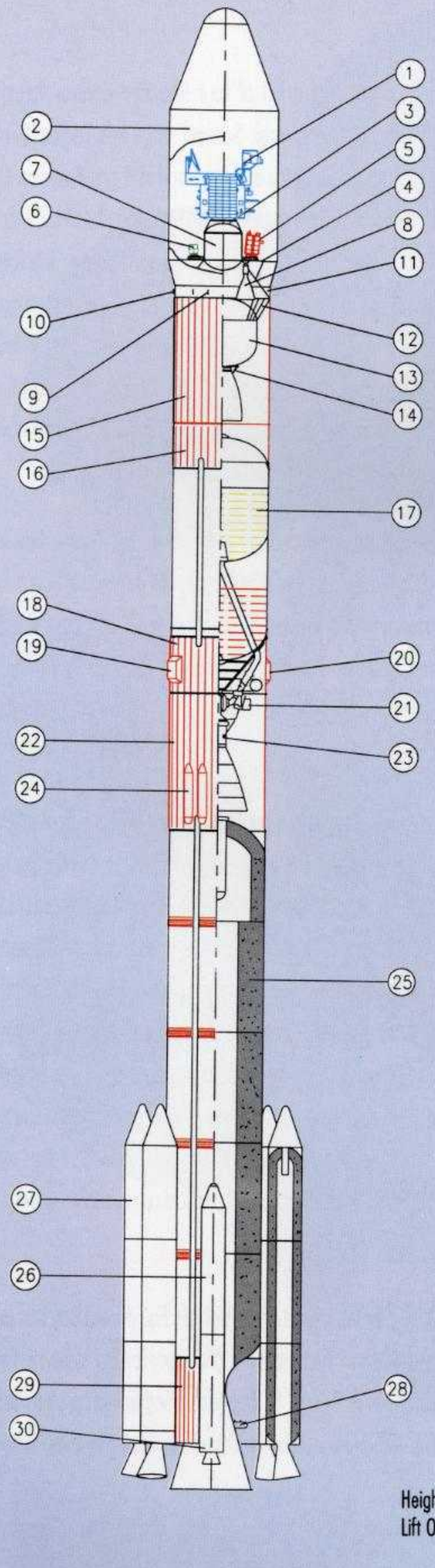
An Inertial Navigation and Guidance System (IGS) in the Vehicle Equipment Bay (VEB) guides the vehicle from lift-off to spacecraft injection. The Digital Autopilot (DAP) and Closed Loop Guidance (CLG) scheme resident in the onboard computer ensure the required attitude manoeuvre and guided injection of the spacecraft into the specified orbit. The CLG is initiated during the second stage thrusting phase after Heat Shield separation. The three axes attitude stabilisation of the vehicle is achieved by the autonomous control system provided in each stage. The first stage is provided with Secondary Injection Thrust Vector Control (SITVC) for pitch and yaw control and two swivellable Roll Control Thrusters (RCT) along with SITVC system in two PSOMs for roll control. After the first stage burnout (during auxiliary control phase), RCT engines are used for yaw and roll control and a set of four Reaction Control Thrusters (RCS) are used for pitch control. Second stage has Engine Gimbal Control system (EGC) for pitch and yaw and Hot gas Reaction Control Module (HRCM) for roll control. The third stage has Flex Nozzle Control (FNC) for pitch and yaw during the thrust phase. The fourth stage is controlled during thrust phase by gimballing its two engines for pitch, yaw and roll. Reaction Control System (RCS) provided in the fourth stage is used for control of pitch, yaw and roll during coast phase. These thrusters are also used for roll control during third stage and post cut-off manoeuvres of the fourth stage.

A bulbous aluminium alloy heat shield of 3.2m diameter protects the spacecraft against the hostile flight environment during ascent phase and is jettisoned at an altitude of 120 km using a pyrotechnic based linear bellow mechanism. The vehicle is provided with various stage separation systems to discard the spent stages at the appropriate times.

The strapon motors are configured with ball and socket joints clamped using frangible nuts while spring thrusters provide the jettisoning energy. The first stage uses Flexible Linear Shaped Cord (FLSC) to sever the interstage structure and the jettisoning is achieved by eight retro rockets. Ullage rockets ensure the positive acceleration of the vehicle during stage separation to enable start up of the liquid engine of the second stage. The second stage separation is based on Merman band and jettisoning is by a set of four retro rockets. The third stage separation is through 'Ball lock' mechanism and springs while fourth stage uses Merman band with helical compression springs for imparting separation velocity.

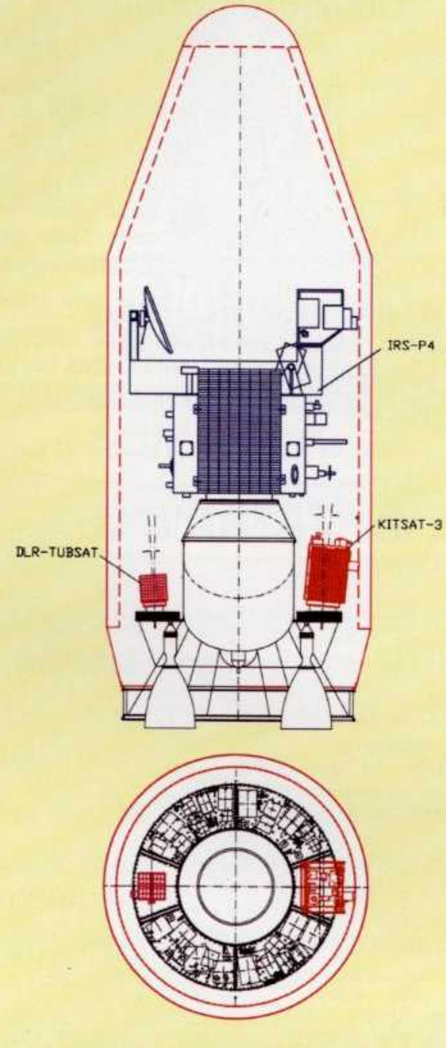
In PSLV-C2, the layout of the Vehicle Equipment Bay has been modified and the Honeycomb deck plate beefed up to carry two auxiliary satellites at P+and P- locations. Separation system based on 'Ball lock' mechanism are employed for the jettisoning of these satellites.

VEHICLE CONFIGURATION



1. IRS-P4 SATELLITE
2. HEATSHIELD
3. PAYLOAD ADAPTOR
4. EQUIPMENT BAY
5. KITSAT-3
6. DLR-TUBSAT
7. FOURTH STAGE PROPELLANT TANK
8. FOURTH STAGE ENGINE (2)
9. ANTENNAE
10. REACTION CONTROL THRUSTER (6)
11. INTERSTAGE 3/4
12. THIRD STAGE ADAPTOR
13. THIRD STAGE MOTOR
14. FLEX NOZZLE CONTROL SYSTEM
15. INTERSTAGE 2/3U
16. INTERSTAGE 2/3L
17. SECOND STAGE PROPELLANT TANK
18. INTERSTAGE 1/2U
19. SECOND STAGE RETRO ROCKET (4)
20. ULLAGE ROCKET (4)
21. GIMBAL CONTROL SYSTEM
22. INTERSTAGE 1/2L
23. SECOND STAGE ENGINE
24. FIRST STAGE RETRO ROCKET (8)
25. FIRST STAGE MOTOR
26. SITVC INJECTANT TANK (2)
27. STRAP-ON MOTOR (6)
28. SITVC SYSTEM
29. CORE BASE SHROUD
30. ROLL CONTROL ENGINE (2)

Height of vehicle	- 44.4m
Lift Off mass	- 294t



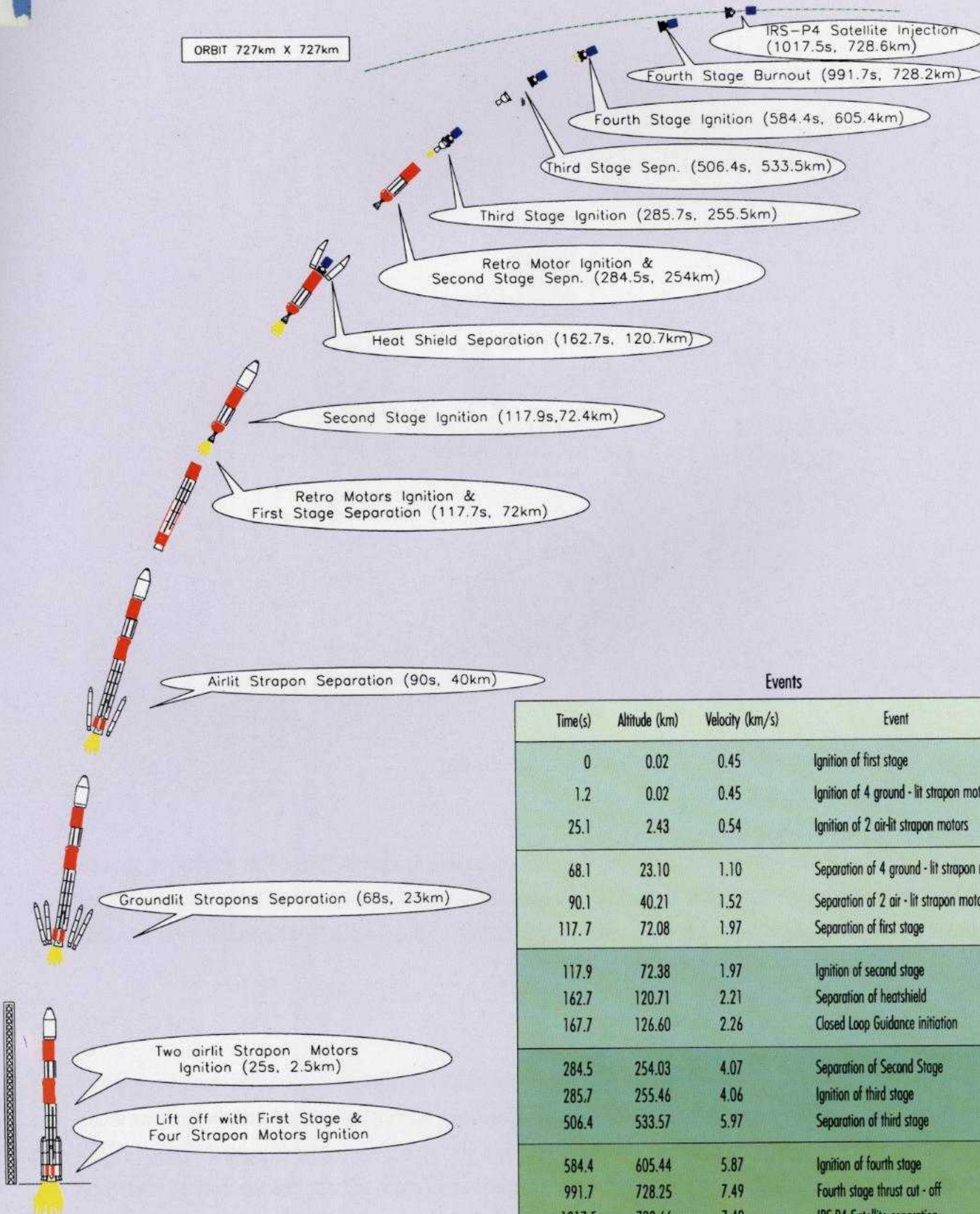
IRS P-4, KITSAT-3 and
DLR-TUBSAT in PSLV - C2 Payload Envelope

The vehicle is also provided with instrumentation to monitor vehicle performance during flight. S-band PCM telemetry systems and C-band transponders cater to these requirements. The tracking systems provide real time information for flight safety and preliminary orbit determination. Telecommand system together with destruct system hardware provided onboard, enable flight termination in case of an errant flight.

FLIGHT SEQUENCE

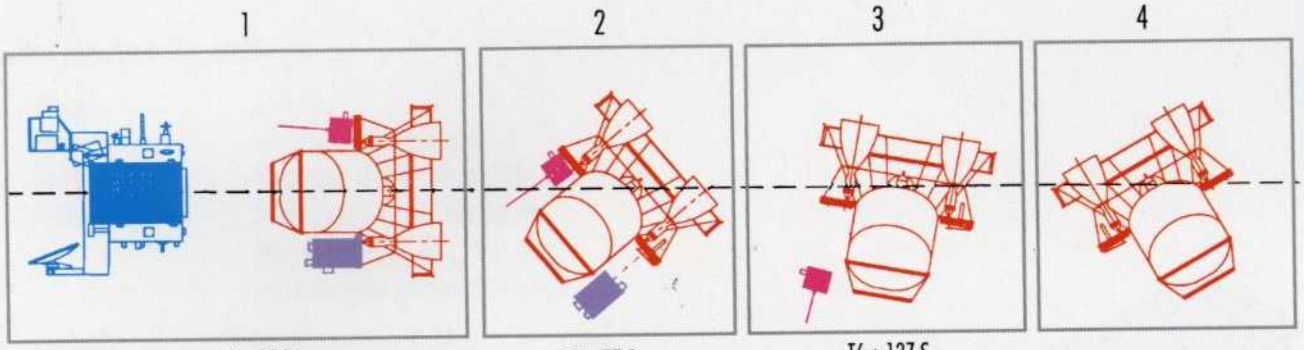
The overall flight sequence is given overleaf highlighting the planned time, altitude and inertial velocity at critical events. However some of the events are decided onboard and the actual time of occurance can vary accordingly. IRS-P4 is separated with a relative separation velocity of 1.14m/s, 50s after PS4 thrust cut off on reaching desired injection conditions. 50s later and after a yaw manoeuvre of 40 deg, the KITSAT is separated. TUBSAT is separated after 50s and after another yaw manoeuvre of 40 deg in the same direction. Both the satellites are jettisoned with a velocity of 1m/s. The selected sequence, the manoeuvre and the velocities ensure the collision free separation of all the satellites from the vehicle and eliminate possibility of subsequent recontact.

PSLV-C2 FLIGHT PROFILE



Events

Time(s)	Altitude (km)	Velocity (km/s)	Event
0	0.02	0.45	Ignition of first stage
1.2	0.02	0.45	Ignition of 4 ground - lit strapon motors
25.1	2.43	0.54	Ignition of 2 air-lit strapon motors
68.1	23.10	1.10	Separation of 4 ground - lit strapon motors
90.1	40.21	1.52	Separation of 2 air - lit strapon motors
117.7	72.08	1.97	Separation of first stage
117.9	72.38	1.97	Ignition of second stage
162.7	120.71	2.21	Separation of heatshield
167.7	126.60	2.26	Closed Loop Guidance initiation
284.5	254.03	4.07	Separation of Second Stage
285.7	255.46	4.06	Ignition of third stage
506.4	533.57	5.97	Separation of third stage
584.4	605.44	5.87	Ignition of fourth stage
991.7	728.25	7.49	Fourth stage thrust cut - off
1017.5	728.66	7.49	IRS-P4 Satellite separation
1067.5	729.51	7.49	KITSAT Separation
1117.5	730.41	7.49	TUBSAT Separation



T6 + 27 S
SEPARATION OF IRS - P4

T6 + 77 S
SEPARATION OF KITSAT AFTER A YAW TURN OF 40 DEG

T6 + 127 S
SEPARATION OF TUBSAT AFTER A YAW TURN OF 80 DEG

SPENT PS4 STAGE YAW TURN 120 DEG

SEPARATION SEQUENCE OF SPACECRAFTS IN PSLV - C2 MISSION

OCEANSAT - 1

IRS-P4 is the fourth spacecraft in the IRS-P series being launched by PSLV. The Spacecraft built by ISRO Satellite Centre, Bangalore will fly Ocean Colour Monitor (OCM) and Multifrequency Scanning Microwave Radiometer (MSMR) mainly to serve Ocean related applications and hence named OCEANSAT-1.

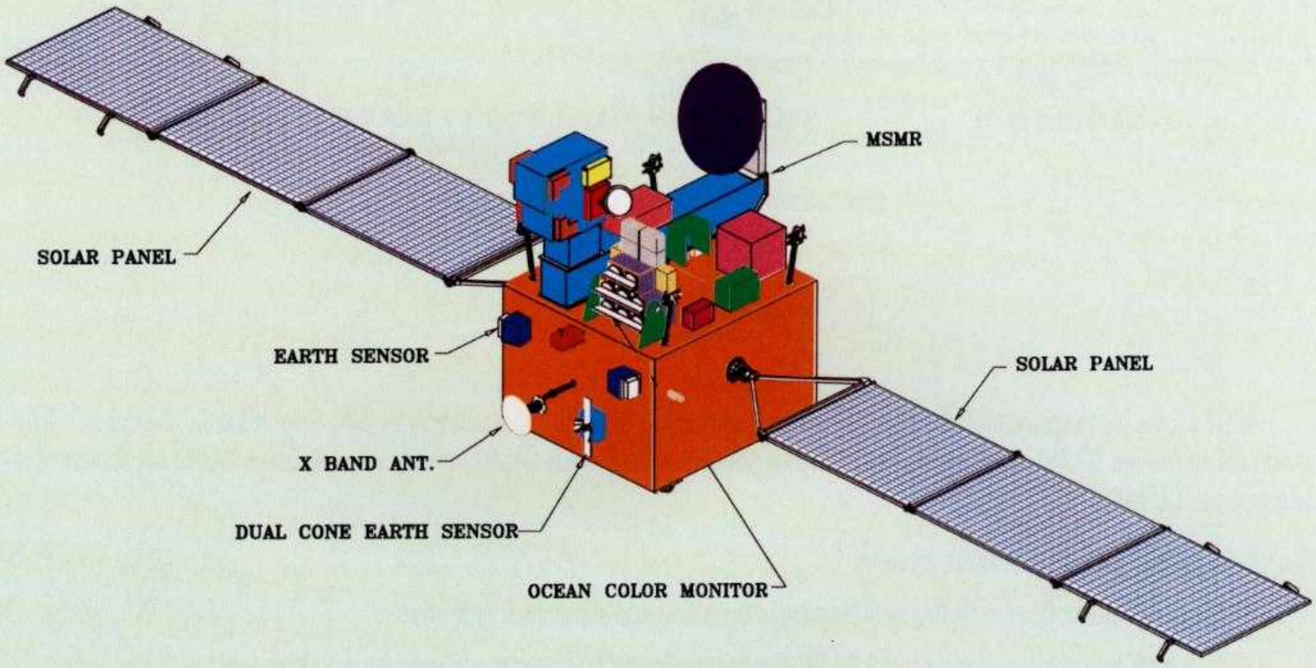
The mission objectives of IRS-P4 are the following

- To gather data for Oceanographic, land (vegetation dynamics) and atmospheric applications
- To develop new application areas using IRS-P4 data as complimentary / supplementary to the data from the already operating remote sensing satellites and
- To provide opportunity for conducting technology / scientific experiments that are of relevance for future developments.

- OCM has 8 bands in visible and near infra red region of electromagnetic spectrum with 20 nanometer band width and 12 bit digitisation. It will provide information on chlorophyl distribution to identify the potential fishing zones and to study coastal areas. With a spatial resolution of 360m, it will also serve land applications. OCM can be operated over any ground station for a period of 12 minutes and facility also exists onboard to record the average data (coarse resolution) for a period of 10 minutes anywhere in the orbit, if the ground station to receive the data does not exist. Inorder to avoid sunlight, OCM can be tilted along track by 20 deg using a motorised tilt mechanism.
- MSMR will provide data on sea surface temperature, liquid water content and water vapour in atmosphere above oceans. It is planned to operate MSMR continuously and collect data globally. Both these payloads put together serve the intended applications.
- IRS-P4 will also fly a Satellite Positioning System (SPS) in order to get better orbit determination accuracy which results in improvement in location accuracy of the imagery.

Physical characteristics of IRS-P4

Mass	1050kg
Shape	Cuboidal
Overall dimensions in launch configuration	2340 X 1990 X 2527 (H) mm
End to end length in deployed mode	11.79 m
Solar panel	9.6Sq.m,
Power	800 w 2 x 21 AH Ni-Cd batteries



DEPLOYED CONFIGURATION OF IRS-P4 SPACECRAFT

PASSENGER PAYLOADS

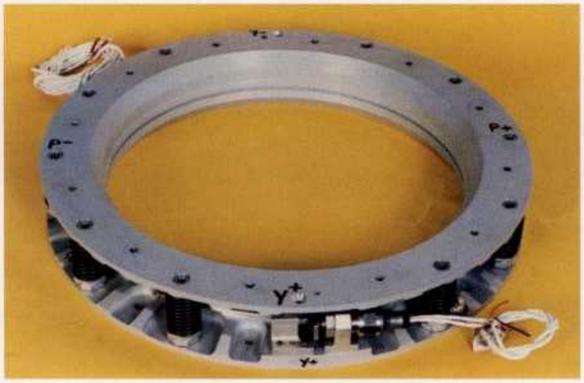
KITSAT - 3

KITSAT-3 developed by Korea Advanced Institute of Science & Technology (KAIST), South Korea is the third experimental micro satellite realised by KAIST. The objective of the mission is to develop and test the following basic micro satellite technologies.

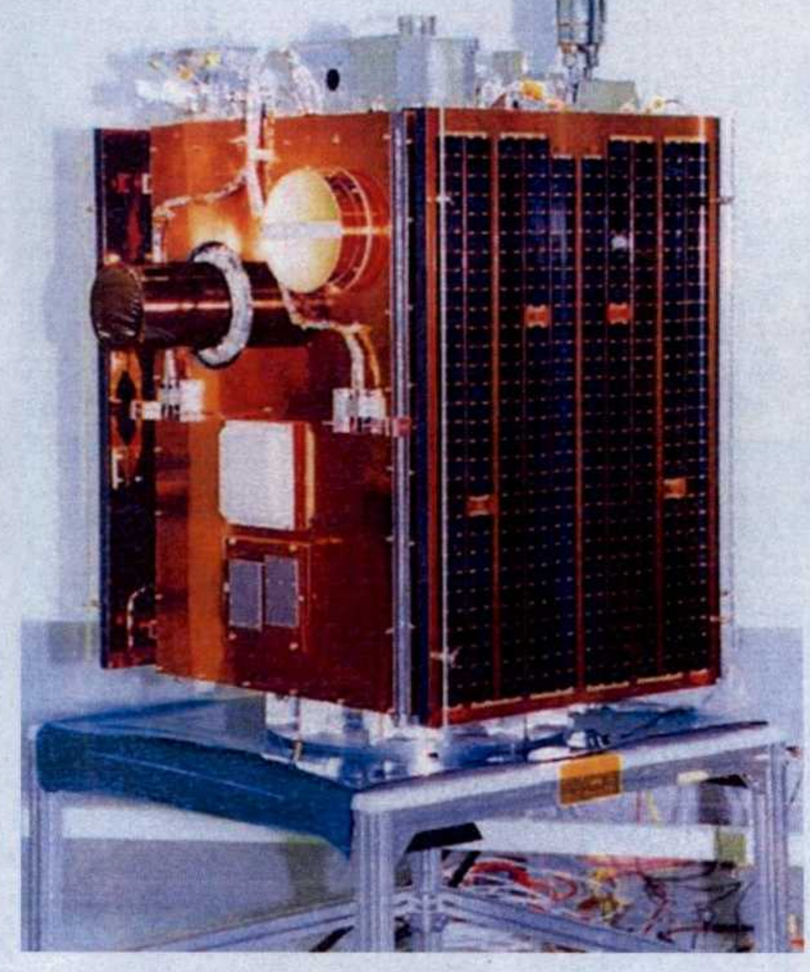
- 3 axis stabilised attitude control
- Common bus architecture
- Solar panel deployment
- High speed data transmission
- Solid state data storage

Salient features of the satellite are

Weight	-	110 kg
Dimensions	-	495x604 x 852(H) mm
Power	-	Maximum 180 w, Deployable solar panels
Attitude Control	-	3 axis stabilised attitude control with star sensors, fibre optic gyros, magnetorquers and reaction wheels
Payloads	-	Remote sensing payload 15m Ground Resolution, 3 channel Linear CCD Camera
	-	Space Science payloads Radiation effects on Micro electronics High Energy particle Telescope Scientific Magnetometer Electron Temperature Probe
Separation System	-	358mm dia, ISRO Ball lock system



KITSAT - 3 separation system



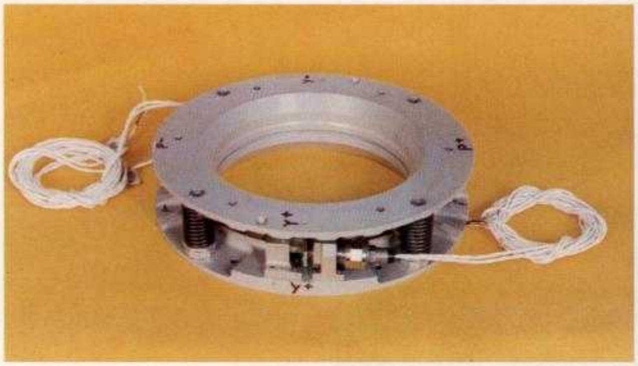
KITSAT - 3

DLR-TUBSAT

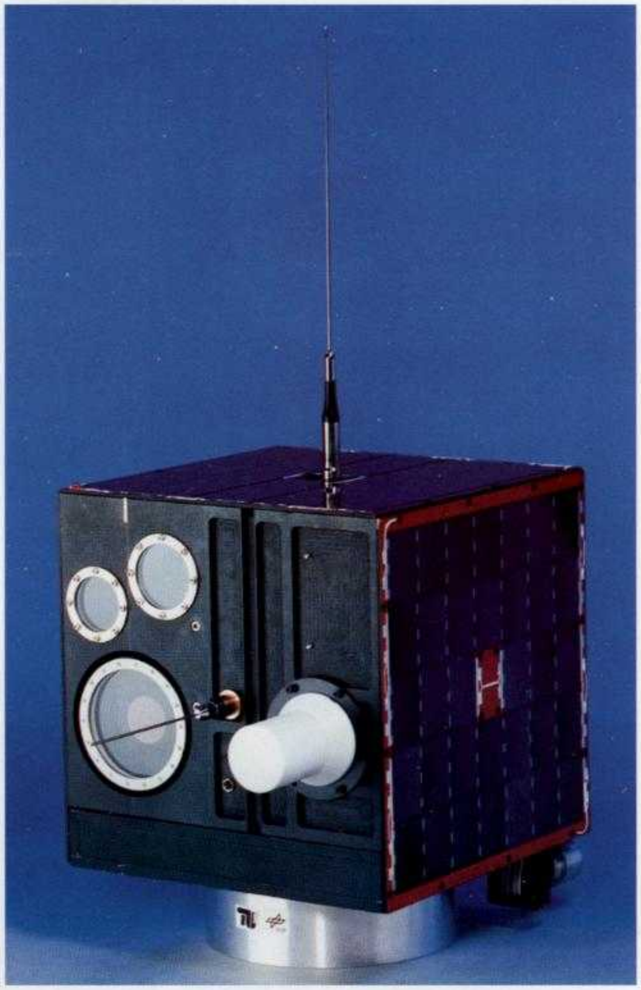
DLR-TUBSAT is a joint project of the DLR Institute of Space Sensor technology and the Technical University of Berlin, Germany. The micro satellite is mainly used to carryout tests involving exact three axes attitude control and to qualify different subsystems with regard to their tasks in target pointing and high resolution earth observation.

The DLR-TUBSAT has a cubic shaped structure and consists of four aluminium shells to housepackages including payloads and sensors. The salient features of the satellite are

Mass	-	45 kg
Dimensions	-	320 x 320 x 320mm
Payloads	-	Three digital cameras with 16mm and 50mm wide angle lens and1000mm tele bus
Power	-	Body mounted solar panels
Attitude Control	-	3 reaction wheels, 3 fibre optic laser gyros, 3 axis star sensor
Battery	-	4Nos of NiH2 cells with 12 AH capacity each
Separation Sysrem	-	230mm dia, ISRO Ball lock system



TUBSAT Separation System



DLR - TUBSAT

TELEMETRY, TELECOMMAND AND TRACKING SYSTEMS

Ground systems and Ground stations play a very important role in confirmation of the mission success, ensuring Range and Flight Safety and Post flight data analysis. Telemetry Tracking and Telecommand (TTC) support to PSLV is provided by the following network of ground stations which track the vehicle and acquire the telemetry data during launch.

SHAR-1 ❖ SHAR-2 ❖ THIRUVANANTHAPURAM ❖ MAURITIUS ❖ BANGALORE

During launch phase, Sriharikota, Thiruvananthapuram, Bangalore and Mauritius ground stations are configured to receive vehicle and satellite telemetry signals. SHAR has Telemetry Tracking & Telecommand facilities and with its redundant configuration, cater to the launch phase upto 680 seconds. Mauritius Down range station can track the vehicle from 700 seconds till 200 seconds after burnout of the fourth stage. Thiruvananthapuram station provides the required space diversity for ensuring continuous telemetry data link. TTC support for spacecraft is provided by Bangalore, Lucknow and Mauritius. In addition, support from external stations such as Bearslake, Biak and Welheim are also taken for the spacecraft operations in the initial phase.

Telecommand system at SHAR is used for Range and Flight safety and to enable flight termination in case of deviation of the vehicle from

the safe trajectory. Tracking is provided by two Precision Coherent Monopulse C-Band Radars (PCMC-1 & PCMC-2) located at SHAR and one PCMC-3 Radar located at Mauritius in conjunction with two onboard C-band transponders as well as through Satellite Range and Range Rate Transponder(SRRT).

Real time data processing support is provided by ground stations for Range Safety, Data display at the consoles at MCC, Preliminary Orbit Determination (POD) and Quick Look Data (QLD) analysis. TTC ground stations are linked with each other through dedicated data links. The data transmission between ground stations is largely carried out through satellite links and partially through dedicated terrestrial links. The ISRO Telemetry Tracking and Command network (ISTRAC) ensures the co-ordinated operation of the various ground stations and provide the necessary services during the mission.

LAUNCH RANGE FACILITIES

The final vehicle and spacecraft preparations, integration, checkout and the launching of the vehicle are carried out at Launch base at Sriharikota Range (SHAR). The SHAR complex located at 80km north east of Chennai (lat. 13. 73, long. 80.24) is ideally located at the east cost of India. The main elements of PSLV launch complex are the following.

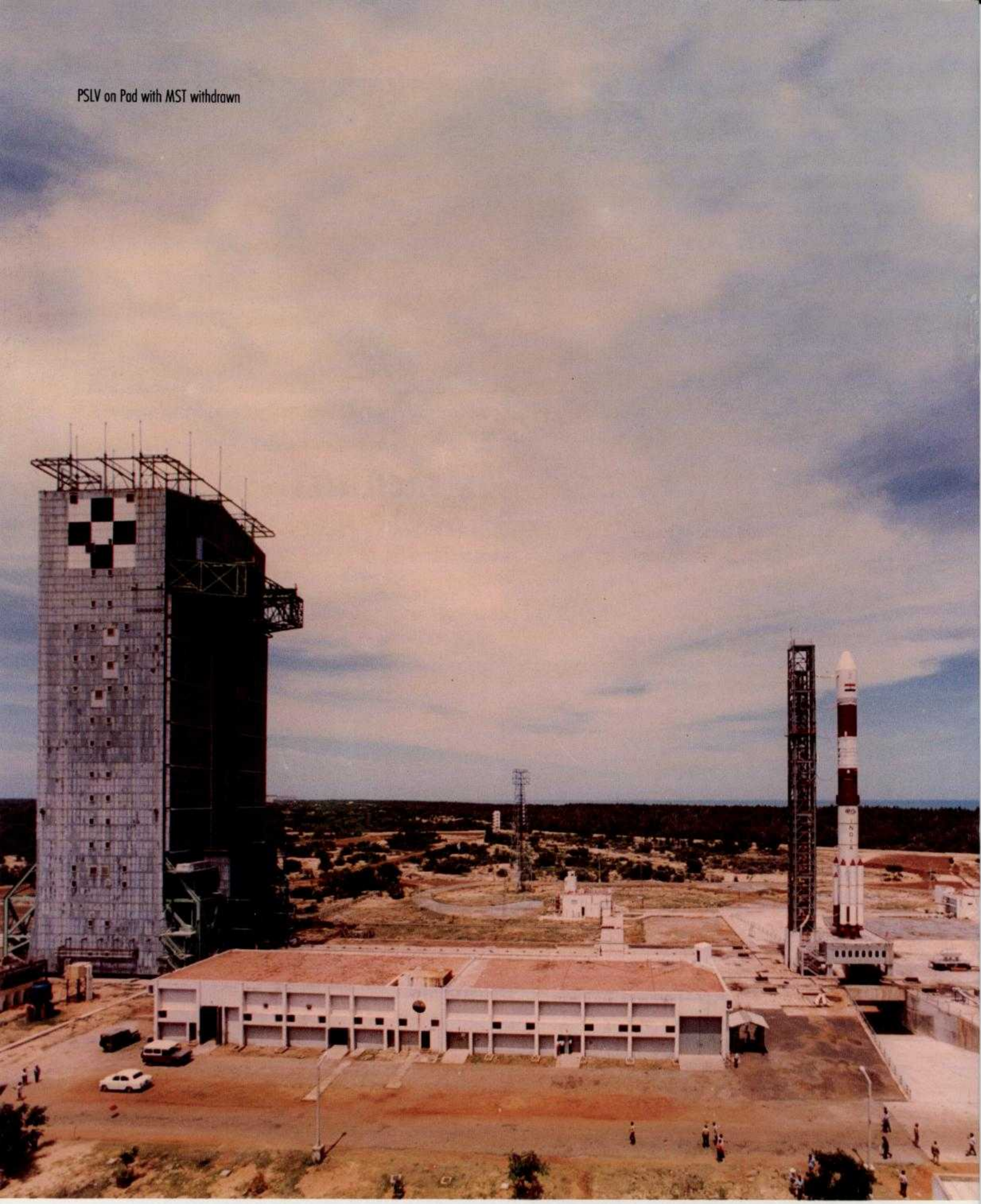
- Mobile Service Tower (MST), Umbilical Tower (UT) & Launch pedestal
- Solid Motor Preparation facility
- Subsystem preparation facility for all interstages, liquid propellant stages, heatshield and spacecrafts
- Liquid propellant storage and transfer facility
- Hardware storage facility for interstages
- Launch Control Centre (LCC) & Mission Control Centre (MCC)
- Range Instrumentation and support facility

The vehicle is vertically integrated over the launch pedestal which is located above the jet deflector and the two exhaust ducts enable smooth flow of the exhaust gases. The Umbilical Tower (UT) provides interface structure through which all the required fluid servicing lines and electrical checkout lines are attached to the vehicle. The 75m tall Mobile Service Tower (MST)is positioned around the lauch pedestal and the UT and provides access and protective enclosure during the vehicle integration. It also houses handling systems and ensures clean environment for the vehicle and satellite. The tower is moved on a rail system to a safe distance of 100m before vehicle lift- off.

Located 5km away from the launch pad, the LCC has facilities for the remote checkout and launch of the vehicle. The LCC houses all the vehicle control consoles, filling consoles as well as checkout and automatic launch systems. It is connected to the launch pad through fibre optic data links communicating in real time to computers as well as specialists' consoles in the appropriate format.

The MCC located adjacent to LCC has consoles for the mission executives who authorise the launch based on readiness of all the systems. The vehicle performance is graphically depicted in large display boards in real time. The range safety console is manned by the Range Safety Officer who is authorised to terminate the vehicle in case of vehicle malfunction which can pose danger to men and materials on ground. The major range Instrumentation and support facilities are

- Tracking systems like Precision 'C' band and 'S'band Radars
- Telecommand System
- Support System like Intercommunication, Closed circuit TV System, Data Links, Range Timing System, Real Time Systems and Specialist display System; and
- Metereology and Technical photography



PSLV on Pad with MST withdrawn

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Printed at San Jose Process, Thiruvananthapuram - 14


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PSLV C5 - IRS P6
MISSION
INDIAN SPACE RESEARCH ORGANISATION

C5 launch preparation

Launch campaign commenced on 30th July '03

Core Base Shroud + Nozzle End Segment

First Stage

Interstage IS 1/2L

Second Stage

Third Stage

Fourth Stage

IRS-P6 Solar Panel Deployed

IRS-P6 Stacked on vehicle

Heat Shield

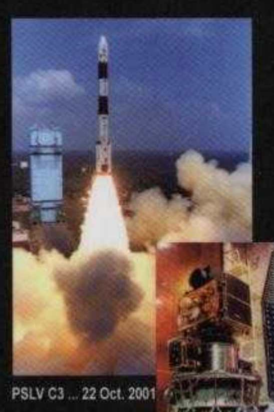
operational flights

PSLV C1 ... 29 Sept. 1997

IRS - 1D

PSLV C2 ... 26 May 1999

IRS-P4 , KITSAT, TUBSAT



PSLV C3 ... 22 Oct. 2001

TES, PROBA, BIRD

PSLV C4 ... 12 Sept. 2002

METSAT

Designed & Published by PSLV Project, VSSC, Valiamala, Thiruvananthapuram • Printed at St. Joseph's Press, Thiruvananthapuram

the space craft

IRS-P6 spacecraft would be the continuity provider for IRS-1C/1D with enhanced capabilities. The Spacecraft has improved payloads compared to those of IRS-1C/1D and has a mass of 1360 kg.

The high resolution three band Multispectral camera (LISS-4) with a resolution of 5.8 meters with additional off nadir viewing capability.

The LISS – III camera operating in 4 spectral bands – 3 bands are identical to IRS-1C/1D and a fourth band is in short wave IR with improved resolution.

The Advanced Wide Field Sensor (AWiFS) operating in 4 bands namely bands 2,3,4 & 5; split as two modules – AWiFs-A & AWiFs-B

the vehicle

The C5 vehicle configuration essentially remains unchanged from PSLV C4 mission. The vehicle is powered by solid propellant first and third stages and liquid propellant second and fourth stages.

- Overall length : 44.4 m
- Lift-off mass : 295.93 t
- First stage : PS1 (S139) + 6 PSOMs HTPB Based Solid
- Second stage : PS2 (PL40) Liquid UH25 + N_2O_4
- Third stage : HPS3 HTPB Based Solid
- Fourth stage : PS4 (PL2.5) Liquid MMH + MON

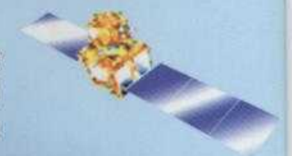
new element

- CFRP PS3 Adaptor : third stage inert mass reduced by 24 kg

changes

- High Pressure engine for second Stage with UH25 / N_2O_4 Propellant combination
- Modified PS1 RCT Structure and Propellant tank
- Use of E^2 PROM in Guidance Control Processor and ECIL rate gyros for Rate Gyro Package
- Redundancy in Automatic Launch Sequence (ALS) monitoring parameters

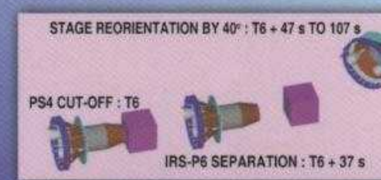
the mission

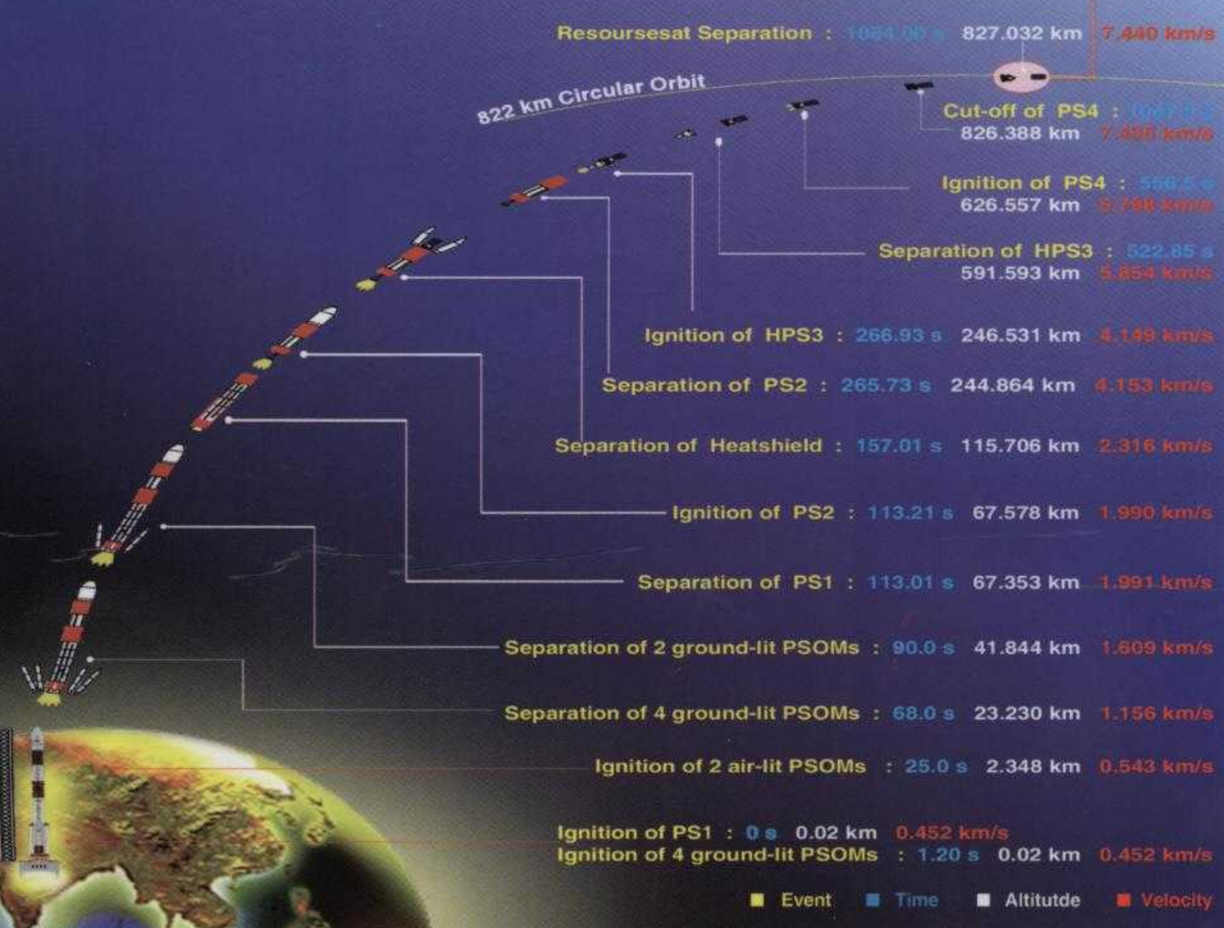


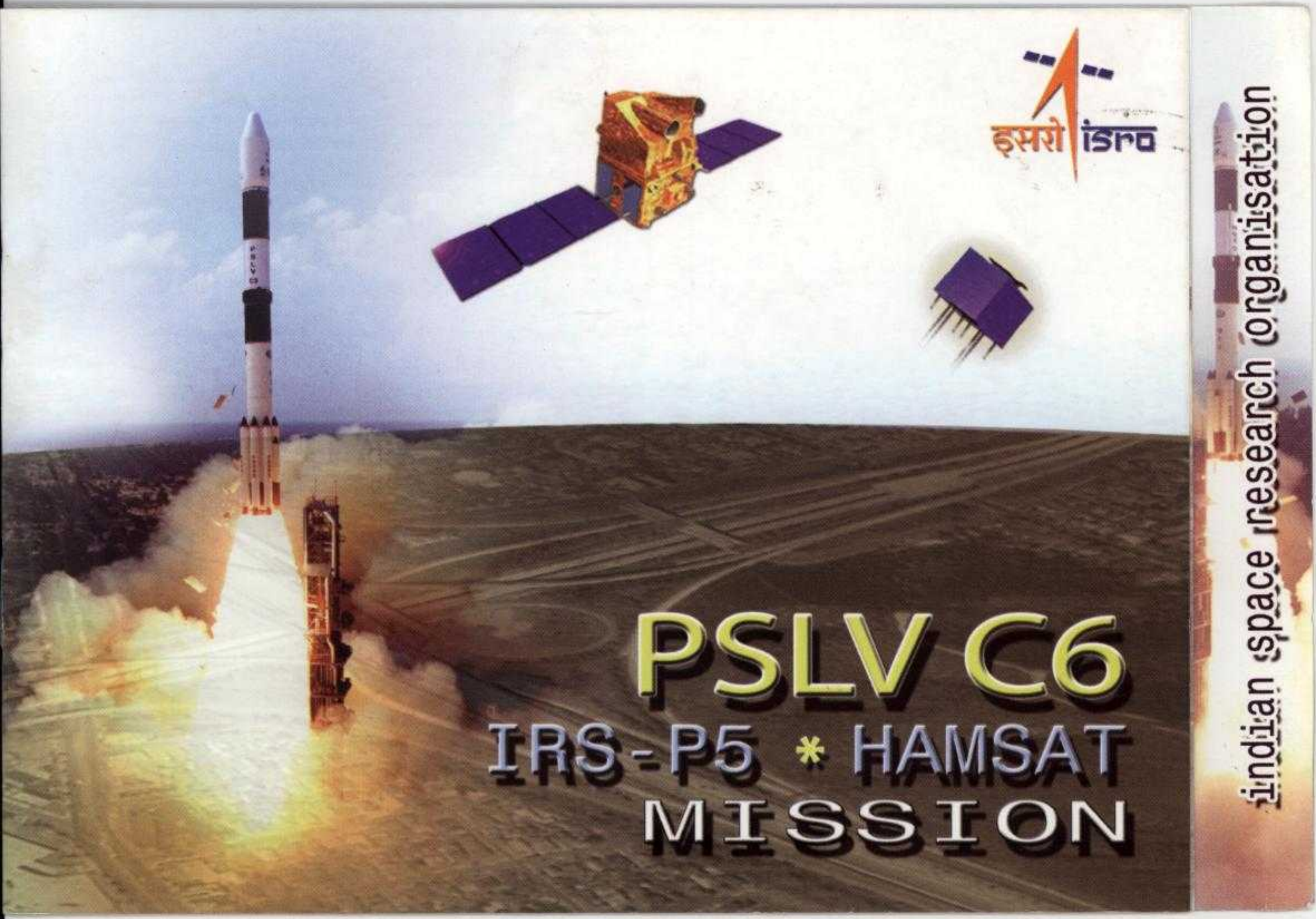
PSLV C5 - the fifth flight in the operational series and eighth flight of the POLAR SATELLITE LAUNCH VEHICLE is identified as a SSPO mission to deploy the satellite RESOURSESAT -1 (IRS - P6) in 822 km circular orbit.

MISSION DEFINITION

Orbit	- Sun Synchronous Polar Orbit (SSPO)
Altitude	- 822 km circular
Inclination	- 98.728 deg.
Orbital Period	- 101.35 minutes
Launch time	- 10:22:08 IST -0 / + 10 min
Launch Azimuth	- 140 deg.



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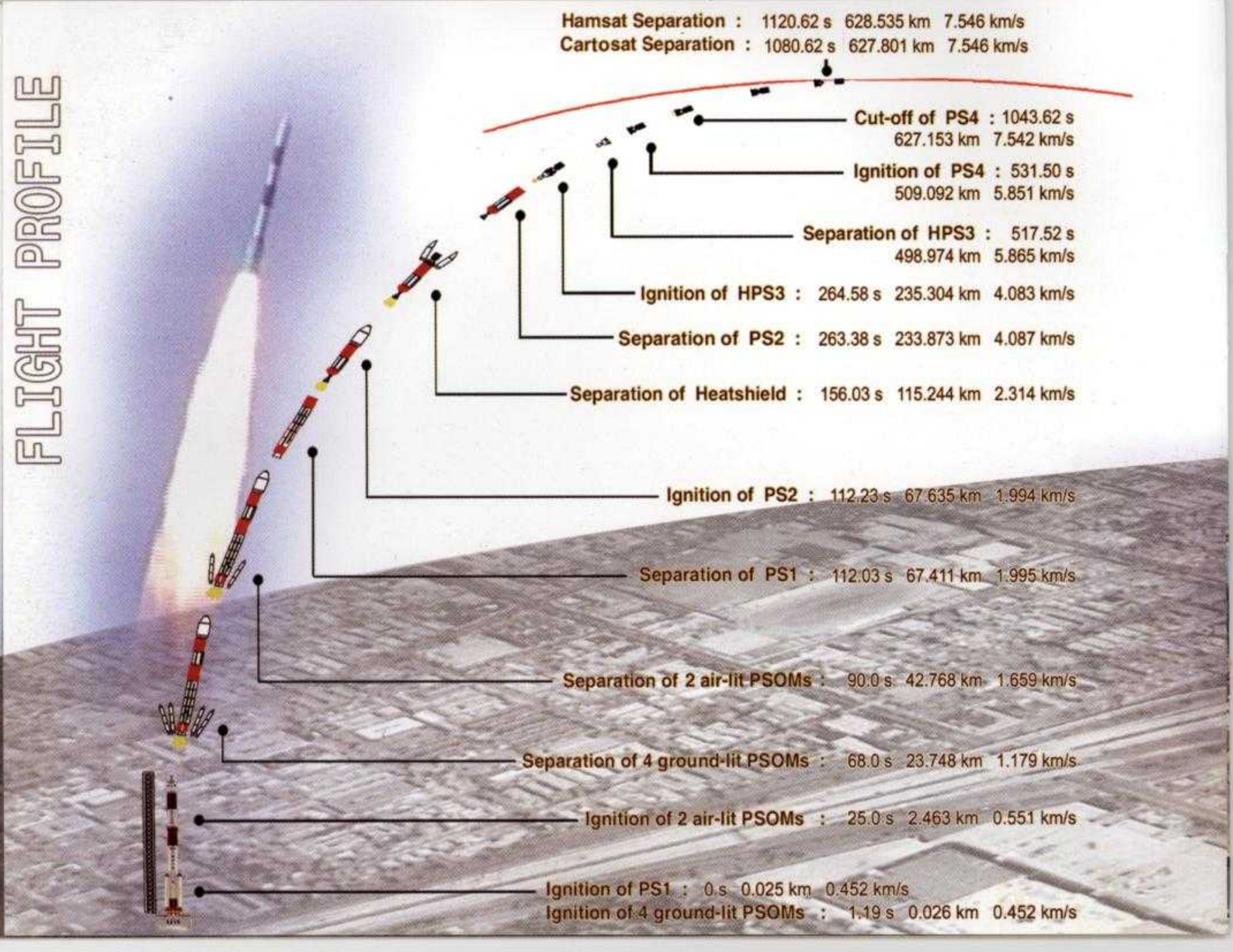
PSLV C6
IRS-P5 * HAMSAT
MISSION
indian space research organisation


FLIGHT PROFILE
Hamsat Separation : 1120.62 s 628.535 km 7.546 km/s
Cartosat Separation : 1080.62 s 627.801 km 7.546 km/s
Cut-off of PS4 : 1043.62 s 627.153 km 7.542 km/s
Ignition of PS4 : 531.50 s 509.092 km 5.851 km/s
Separation of HPS3 : 517.52 s 498.974 km 5.865 km/s
Ignition of HPS3 : 264.58 s 235.304 km 4.083 km/s
Separation of PS2 : 263.38 s 233.873 km 4.087 km/s
Separation of Heatshield : 156.03 s 115.244 km 2.314 km/s
Ignition of PS2 : 112.23 s 67.635 km 1.994 km/s
Separation of PS1 : 112.03 s 67.411 km 1.995 km/s
Separation of 2 air-lit PSOMs : 90.0 s 42.768 km 1.659 km/s
Separation of 4 ground-lit PSOMs : 68.0 s 23.748 km 1.179 km/s
Ignition of 2 air-lit PSOMs : 25.0 s 2.463 km 0.551 km/s
Ignition of PS1 : 0 s 0.025 km 0.452 km/s
Ignition of 4 ground-lit PSOMs : 1.19 s 0.026 km 0.452 km/s

PSLV C6 MISSION

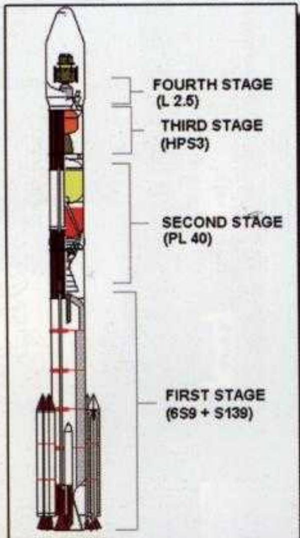
PSLV C6, the sixth operational flight of Polar Satellite Launch Vehicle (PSLV) carries ISRO's remote sensing satellite Cartosat - 1 (IRS-P5) and a micro-satellite Hamsat

This ninth flight of PSLV is the maiden launch from the new launch pad designated as Second Launch Pad (SLP)

MISSION DEFENITION

Orbit	:	**Sun Synchronous Polar**
Altitude	:	**622 Km circular**
Inclination	:	**97.89 deg**
Orbital Period	:	**5829 s**
Launch time	:	**10:19 Hrs IST**

VEHICLE



Overall Height : 44.4 m
Lift-off weight : 295.98 t

The vehicle configuration for PSLV C6 mission essentialy remains same as PSLV C5 except for the following majors changes related to vehilce elements

- Remote Fill and Drain System (RFDS) for second stage propellant servicing
- Mk-II version base ring for four strap-on motors
- Indigenous hydraulic pump for PS2 Engine Gimbal Control System
- Indigenous torque motor for PS4 Control System
- Monolithic igniter with C-600 initiation for strapon motors
- Indigenous Columbium divergent for PS4

The changes with respect to mission management are the adoption of the Day of Launch (DOL) wind biasing and commanded cut-off of second stage to avoid N_2O_4 depletion so as to reduce vibration levels at satellite interface.

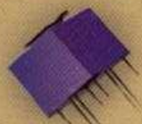
PAYLOADS

CARTOSAT - 1 (IRS - P5)

India's first cartography (mapping) satellite is intended for cartographic imaging in addition to other remote sensing application

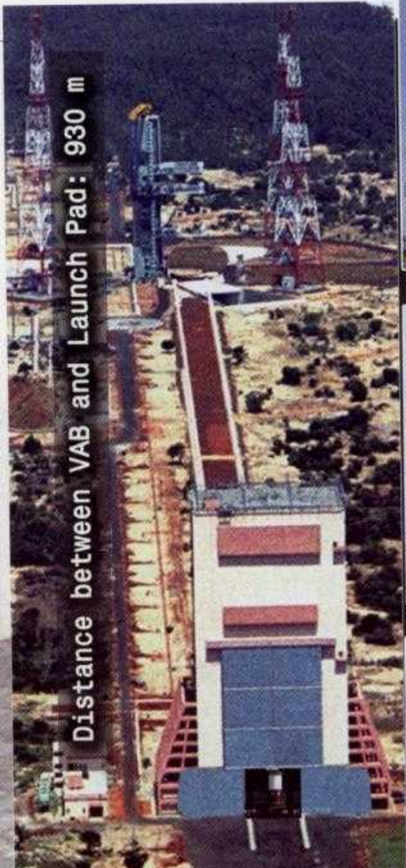
- **Mass :1560 kg**
- Twin PAN cameras providing steroscopic image pairs
- 2.5 m spatial resolution

HAMSAT



Radio communication micro-satellite developed by ISRO to boost communication among ameture radio operators (HAMs)

- **Mass :42.5 kg**
- Two transponders providing for two way communication



UMBILICAL TOWER (UT) / LAUNCH PAD (LP)

- Octogonal shaped UT to minimise wind and vehicle exhaust loads
- Optimum stand-off distance between UT and vehicle : 12 m
- Tower Height - 70 m
- Three Swivellable Cum Vertically Re-positionable platforms (SCVRP)
- Tower crane of 10 T capacity

MOBILE LAUNCH PEDESTAL (MLP)

- 600 T MLP realised with heavy thick steel plates
- MLP movement achieved by four hydraulically driven bogies, each fitted with 150 T capacity wheels
- Max. Speed with vehicle : 10 m/ min
- Four numbers of 600 T jacks used for anchoring and de-anchoring of pedestal

VEHICLE ASSEMBLY BUILDINING (VAB)

- Tallest building in east coast
  Height - 82.5 m Length - 32.5 m Width - 40 m
- Designed to cater PSLV, GSLV, their variants and advanced launch vehicles
- Six sets of Foldable Cum Vertically Re-positionable Platforms (FCVRP)
- Crane capacity : 200t / 30 t
- One lakh class clean room with conditioned environment and 10 t crane

SECOND LAUNCH PAD

SLP is located 1.5 km south of First Launch Pad (FLP). Integrate, Transfer and Launch (ITL) concept is adopted for launch vehicle at SLP whereas in FLP, vehicle is integrated at launch pad and Mobile Service Tower (MST) is withdrawn after vehicle integration and final check prior to launch

SLP VALIDATION TRIALS

Extensive trials were carried out to validate second launch pad and its facilities to enable PSLV launch from SLP.

- Vehcile integration mockup and movement
- PS2/L-40/PS4/RCS propellant mockup and gas charging trials
- Satellite cooling / purging trials
- Azimuth alignment trials
- Vehicle electrical / pneumatic umblical anchoring trials
- Validation of new checkout system at VAB and launch pad
- Validation of new propellant servicing system
- Pneumatic umblical retraction tests to validate increased stand-off distance

SLP CHECKOUT SYSTEM

At second launch pad, the vehicle is tested using two new checkout systems : one at VAB terminal room (VTR) and one at launch pad terminal room (LTR). Both systems are identical in nature and designed with indigenous VXI systems with high degree of redundancy

- Remote checkout concept
- Independent checkout systems for VTR and LTR
- Network (LAN) extension from Launch Control Centre (LCC) to LTR and VTR
- Redundancy in circuit level as well as system level
- Redundancy in power both in AC level as well as DC level
- Design caters to PSLV, GSLV and future vehicles like gsLV Mk-III
- Easy to reconfigure
- Hardlines for critical vehicle safing commands

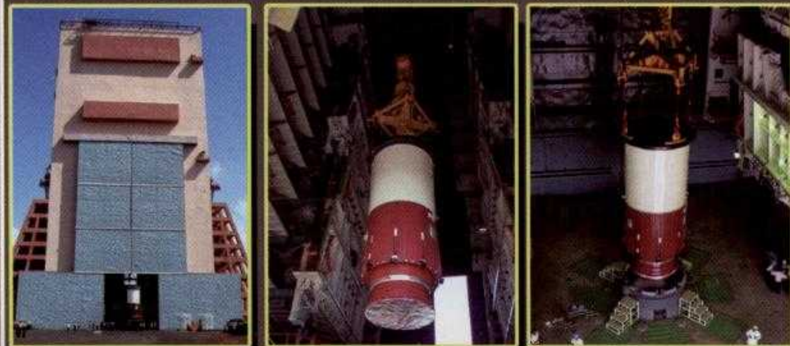

LTR CHECKOUT SYSTEM


VTR CHECKOUT SYSTEM

OPERATIONAL FLIGHTS

C6 LAUNCH

• PSLV C6 flight preparation



Core Base Shroud + Nozzle end segment stacking at VAB

PS1 segment stacking at VAB

PS2 Stage

HPS3 Motor

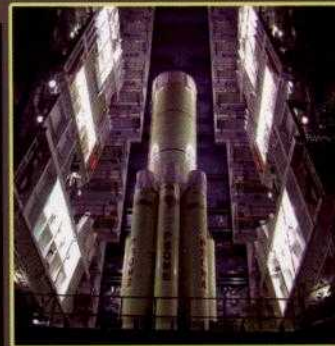
PS4 Stage

Vehicle upto EB during limited

CAMPAIGN

commenced on 5th Jan 2005

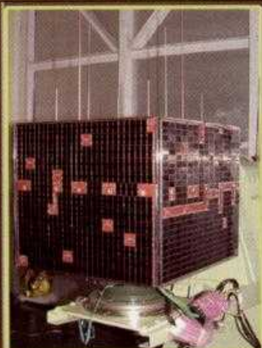
Strap-on stacking at VAB



Core + Strap-ons

Inter Stage 1/2 L

checks



Hamsat

IRS - P5

Payloads integrated to Vehicl

Heat Shield

indian space research organisation

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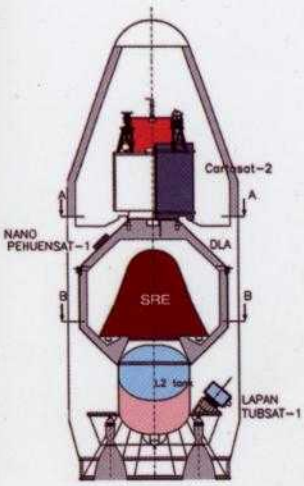
PRINTED AT : St. JOSEPH's PRESS, TRIVANDRUM

design & layout : ss vinod / pslv project


INDIAN SPACE RESEARCH ORGANISATION
PSLV C7
CARTOSAT - 2 / SRE
MISSION

PSLV C7 MISSION



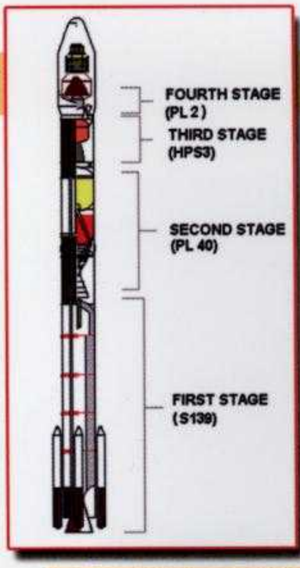
PSLV-C7, the seventh operational flight of Polar Satellite Launch Vehicle is primarily aimed at deploying ISRO's remote sensing satellite CARTOSAT-2 and the Space Capsule Recovery Experiment module SRE. This tenth flight in PSLV series also carries two passenger payloads viz., LAPAN TUBSAT from Indonesia and NANO PEHUENSAT from Argentina. The launching of two numbers of 600 kg class satellites in a single launch is made feasible with the use of a structure called Dual Launch Adapter (DLA). The dual launch concept is being attempted by ISRO for the first time.

MISSION SPECIFICATION

Orbit	:	635.4 km SSPO
Inclination	:	97.92 °
Launch time	:	09:23 hrs IST
Launch station	:	First Launch Pad
Launch Azimuth	:	140 °

MAJOR CHANGES

- Altitude based Day of Launch (DOL) wind biased steering program during Open Loop Guidance
- Deletion of SITVC system of airlit strap-on
- Reduction of PS1 SITVC injectant loading by 500 kg
- Use of externally fabricated nozzles for two PSO motors
- Use of Dual Launch Adapter (DLA)
- Use of 2 t liquid stage for PS4 stage
- Video Imaging System to capture payloads (Cartosat-2 & SRE) and DLA separation events
- Vehicle Structural dynamic characteristics change due to internal vehicle length increase by 2.25 m with the introduction of DLA
- Flight sequence modified to cater to multiple satellite / DLA separation



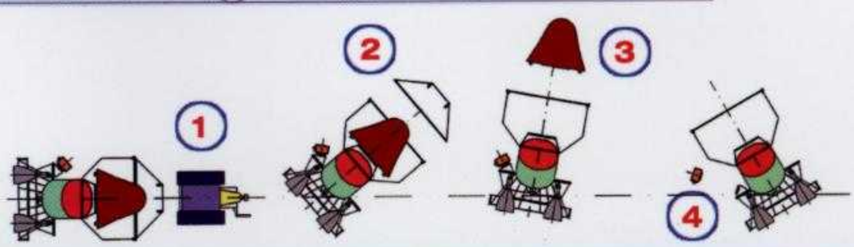
VEHICLE

The vehicle configuration for PSLV C7 mission essentially remains same as PSLV C6 except for the changes mentioned under the section major changes.

Overall height	:	44.4 m
Lift-off mass	:	295.26 t
First stage	:	PS1 (S139) + 6 PSOMs, HTPB based Solid propellant
Second stage	:	PS2 (PL40), UH25 + N_2O_4 Liquid propellant
Third stage	:	HPS3, HTPB based Solid propellant
Fourth stage	:	PS4 (PL2), MMH + MON Liquid propellant

FLIGHT PROFILE

EVENT	TIME (s)	ALTITUDE (km)	VELOCITY (km/s)
Ignition of PS1	0.0	0.024	0.452
Ignition of 4 ground-lit PSOMs	1.2	0.024	0.452
Ignition of 2 air-lit PSOMs	25.0	2.528	0.551
Separation of 4 ground-lit PSOMs	68.0	23.757	1.135
Separation of 2 air-lit PSOMs	90.0	42.768	1.628
Separation of PS1	113.63	70.008	1.989
Ignition of PS2	113.83	70.239	1.988
Heat Shield Separation	159.63	121.957	2.300
Separation of PS2	264.62	235.934	4.067
Ignition of PS3	265.82	237.303	4.064
Separation of PS3	513.36	496.624	6.070
Ignition of PS4	533.50	512.238	6.048
Cut-off of PS4	942.56	638.613	7.536
Cartosat-2 Separation 1	979.56	639.194	7.539
DLA-U Separation 2	1024.56	639.943	7.539
SRE Separation 3	1099.56	641.271	7.539
Lapan-Tubsat Separation 4	1169.56	642.554	7.538



DUAL LAUNCH ADAPTER

DUAL LAUNCH ADAPTER (DLA), is developed for carrying two medium class (~1000 kg) satellites in PSLV. DLA, made of honeycomb sandwich shells with Carbon fibre composite (G969 /Epoxy) facing sheets and Aluminium core, is configured as three substructures viz., DLA-U (Upper), DLA-M (Middle) and DLA-L (Lower). End rings made out of Aluminium AA2014 alloy is provided at both ends of all the three substructures. DLA-U and DLA-L are conical structures while DLA-M is a cylindrical structure

DLA is mounted on PS4 tank by bolting DLA-L along with Payload Adapyer (PLA). Aft end of DLA-M is bolted to DLA-L forward end. DLA-U is placed on top of DLA-M and assembled together by a band clamp separation system. DLA-U carries top payload, Cartosat-2 through a band clamp separation system and second payload, SRE is mounted on PLA fore end through another band clamp separation system. DLA is provided with cutouts of various sizes to facilitate assembly of structure, sensors, electrical connectors and cooling of satellite mounted on PLA.

DLA is a long structure which is encapsulated in payload fairings and it has to carry a satellite of significant mass at the forward end, which will cause some changes in the dynamic characteristics of the vehicle particularly during the PS4 regime. Hence all dynamic characteristics and response of the vehicle at important dynamic events like PS2 burn-out, responses to gust and vibration characteristics are re-evaluated to asses the impact on digital autopilot design, payload envelope estimation and satellite responses. Dynamic characterization test, structural test, re-verification of dynamic characterization and separation test were carried out as part of qualification of DLA.

SRE INTEGRATION WITH DLA & VEHICLE

CARTOSAT-2

INDIA 684 kg

CARTOSAT-2 spacecraft is primarily designed to meet the cartographic requirements of the nation and is equipped with a better than 1 m resolution remote sensing camera. The primary mission objectives of the spacecraft are :

- Obtaining high resolution scene specific spot imageries from a highly agile platform in step and stare mode
- Generating maps for land use planning and urban survey

The above objectives are met using linear array 12k CCD panchromatic camera. The orbit is decided based on the illumination and revisit time. The revisit cycle is 4 days for the 635 km SSPO. The S/C is expected to have a mission life of 5 years. It also has a provision to come down to 560 km and go back to 635 km once in its lifetime.

The S/C will use for the first time a Bus Management Unit (BMU) that supports Telemetry, telecommand, sensor processing, thermal control and control electronics. This replaces three separate packages that were used in the earlier S/Cs for the same functions. The S/C power system consists of four deployable solar panels and two 18 Ah batteries to provide power for peak demand in eclipse mode. The RCS system uses monopropellant of Hydrazine for in-orbit control. The S/C attitude control is achieved by sun pointing and star trackers. Magnetometers are used for coarse attitude references based on knowledge of local geometric field and measurement in three orthogonal axes.

Cartosat-2 will be the first spacecraft to fly on top of the DLA and the separation system employing the band clamp mechanism will provide a separation velocity of around 1.2 m/s.

CARTOSAT-2 INTEGRATION SEQUENCE

SRE

INDIA 555 kg

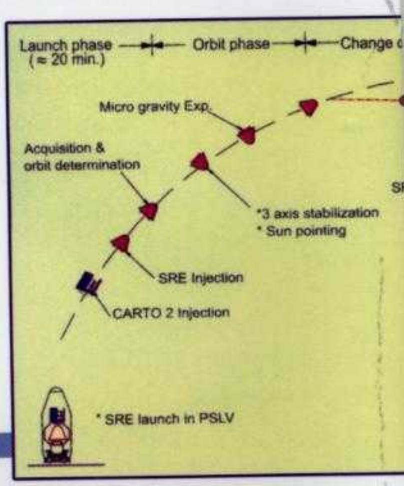
The main objective of **Space Capsule Recovery Experiment (SRE)** mission is to demonstrate our capability to recover an orbiting capsule safely back on earth. It will also provide a platform for conducting long duration orbital microgravity experiments. The sphere-cone-flare shaped SRE capsule, having a total mass of 555 kg, is the first spacecraft to be accommodated inside the DLA on the PLA. The separation system is band clamp system with a separation velocity of around 0.9 m/s.

In orbit, SRE will be in 3 axis stabilized sun pointing mode and two microgravity experiments will be carried out : ICO crystal growth Ga-Mg-Zn alloy (IISc- VSSC) and Bio mimetic material synthesis of hydroxy aptite (National Metallurgical Laboratory, Jamshedpur).

After being in orbit for 12 days, SRE will be de-boosted for re-entry under closed loop guidance and enters atmosphere at 100 km altitude with a speed of 7.9 km/s at M 30. The aerodynamic braking provided by drag of its shape will reduce the velocity to 95 m/s at 5 km. During 80 km to 30 km flight, SRE will be subjected to severe aerodynamic heating (250 W/cm^2) and deceleration (9 g). The thermal protection system, consisting of Carbon phenolic nose cap, reusable Silica tiles in cone flare region and low density ablatives at flare end, will protect the internal packages from heating.

Since the plasma generated by aerodynamic heating surrounds the module, there will be communication blackout. SRE is equipped with a number of useful aero-thermo-structural measurements. During blackout, the data will be stored in memory and will be played back to ground stations once it comes out of blackout around 40 km.

Below 5 km, the deceleration of the capsule to 12 m/s at splash down is achieved using a three stage parachute system. The module will splash down in the sea 140 km off SHAR coast and will float with the aid of a flotation system. With the help of locating beacons and coloring dye , SRE will be recovered by Indian Coast Guard with assistance from Indian Navy. The key technologies developed for SRE, such us reusable thermal protection system, NGC for de-boost, models for hypersonic aero-thermo dynamics, space qualified parachute systems, locating aids, etc., will lay a strong foundation for our Reusable Launch Vehicle technologies.



LAPAN - TUBSAT

INDONESIA 56 kg

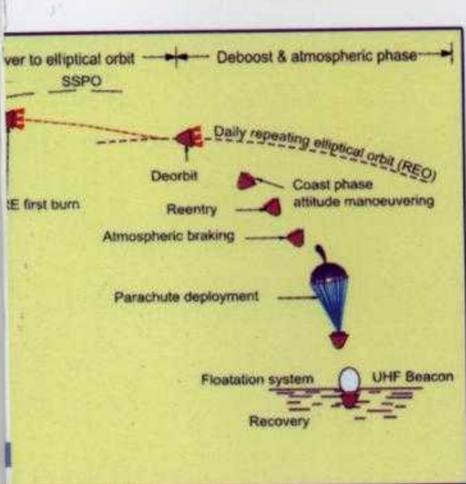
LAPAN-TUBSAT is a video surveillance microsatellite developed as a cooperation project between Lembaga Penerbangan dan Antariksa National of Indonesia and Institute fur-Ind Raumfahrt of TU Berlin, Germany. The S/C attitude and so the camera pointing can be manipulated off-nadir thereby shortening the ground repeat time which otherwise will take longer time.

The payload consists of a wide angle camera and a 5 m resolution camera. While the wide angle camera is used to determine and select the general location of imaging, the high resolution camera is used to zoom in to the area to obtain better images. The S/C also conducts store and forward communication experiments with Indonesian Radio Amateur Society and Universities. One of the objectives of this mission is to collect data on volcanic activity from sensors on the mountains and transmit to the University's ground station. The power system consists of five NiH_2 batteries with 8Ah rating and 12.5V and four body mounted solar panels.

NANO PEHUENSAT

ARGENTINA 6 kg

NANO PEHUENSAT is a small microsatellite developed by the Argentine Association for Space Technology, an educational, non-profit organization based in Buenos Aires, Argentina, jointly with the University of Comahue of Argentina and AMSAT (Amateur Satellite Association of Argentina).



NANO PEHUENSAT provides an experiment platform to perform amateur radio experiments between colleges and universities of Argentina and other countries. The satellite has a voice digitalizer and will transmit satellite health parameters to Earth in three languages : Spanish, English and Hindi. The data can be received using a 148 MHz HAM receiver. The S/C is expected to have a mission life of one month and will orbit the earth along with DLA-U.

C7 LAUNCH CAMPAIGN ACTIVITIES

CBS + NES

STRAP-ON MOTOR

FIRST STAGE

SECOND STAGE

THIRD STAGE

FOURTH STAGE

DUAL LAUNCH ADAPTER

SRE + CARTOSAT-2
AT LAUNCH PAD

OPERATIONAL FLIGHTS

PSLV-C1	29 September 1997	IRS-1D
PSLV-C2	26 May 1999	IRS-P4, KITSAT, TUBSAT
PSLV-C3	22 October 2001	TES, PROBA, BIRD
PSLV-C4	12 September 2002	KALPANA-1
PSLV-C5	17 October 2003	IRS-P6
PSLV-C6	5 May 2005	IRS-P5, HAMSAT

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PRINTED AT : ST. JOSEPH's PRESS, TRIVANDRUM

design : ss vinod / pslv project

INDIAN SPACE RESEARCH ORGANISATION

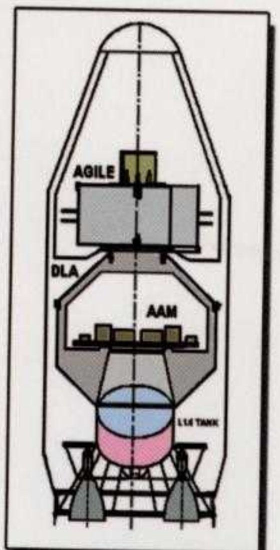
PSLV C8 - AGILE / AAM MISSION

PSLV-C8, the eight operational flight of Polar Satellite Launch Vehicle, is the first full commercial launch of ISRO. The launch is to inject AGILE, a 352 kg Italian Spacecraft developed for Italian Space Agency (ASI) into 550 km circular orbit with 2.5 ° inclination.

In addition to Agile, PSLV C8 will also carry an ISRO payload named Advanced Avionics Module (AAM) as co-passenger in Dual Launch Mode. Agile is mounted on top of the Dual Launch Adaptor (DLA), that sits over the tank of fourth stage of PSLV while AAM is inside the DLA.

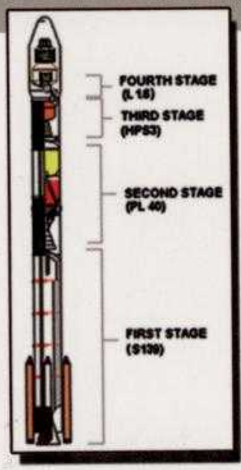
MISSION SPECIFICATION

Orbit	:	550 km circular
Inclination	:	2.5 °
Launch time	:	15:30 hrs IST (10:00 hrs GMT)
Launch station	:	Second Launch Pad
Launch Azimuth	:	99 °



PSLV-C8, is significant in the sense that this is the first mission that does not employ any of the solid strap-ons, that have been used in earlier flights. This configuration of the vehicle termed as PSLV-CA (Core Alone) has been chosen considering the lower payload capability required for Agile and capability of the vehicle as such. C8 is also the first flight in which PSLV is launching a satellite into a circular orbit of very low inclination (2.5 °).

VEHICLE

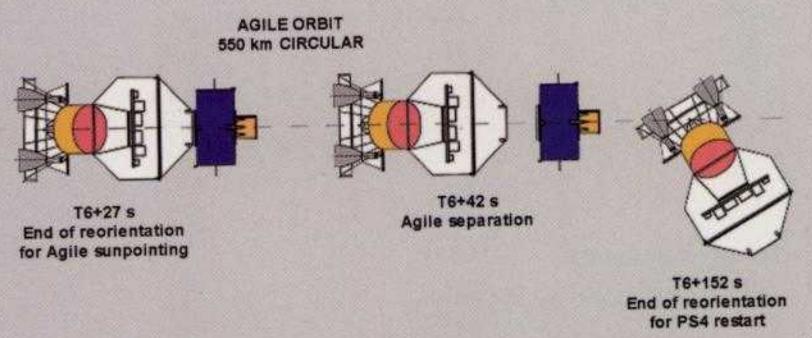


The Core-Alone vehicle configuration of PSLV (PSLV-CA) is employed for the C8 mission. The strap-on motors are not employed while the other propulsive elements and subsyetms essentially remain same as in PSLV C7 except for the changes mentioned under the section Major changes.

Overall height	:	44.4 m
Lift-off mass	:	228.27 t
First stage	:	PS1 (S139) HTPB Solid propellant
Second stage	:	PS2 (PL40), UH25 + N_2O_4 Liquid propellant
Third stage	:	HPS3, HTPB Solid propellant
Fourth stage	:	PS4 (PL1.6), MMH + MON Liquid propellant

MAJOR CHANGES

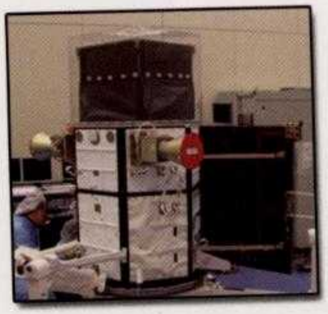
- Core-Alone vehicle
- On-board guidance and control software design modified to meet low inclination requirements
- Use of Aerodynamic Stabiliser (AST) hardware in P+ P- axis for stability
- Flight testing of Advanced Mission Computers and Advanced Inertial Navigation Systems / Advanced Telemetry System in piggyback mode
- New checkout system for AAM
- Induction of AA6061 water tank instead of AA7020 in PS2 stage
- Use of 1.6 t propellant tank for PS4 stage
- Anchoring scheme during movement of vehicle from Vehicle Assembly Building to Launch Pad



SEPARATION SEQUENCE AFTER PS4 CUT-OFF

EVENT	TIME (s)	ALTITUDE (km)	VELOCITY (km/s)
Ignition of PS1	0.0	0.025	0.452
Separation of PS1	112.9	50.07	1.737
Ignition of PS2	113.2	50.25	1.736
Heat Shield Separation	202.9	115.9	2.950
Separation of PS2	263.7	147.2	4.743
Ignition of PS3	264.9	147.8	4.742
Separation of PS3	517.8	282.8	7.581
Ignition of PS4	1033.0	507.7	7.317
Cut-off of PS4	1331.8	550.0	7.583
Agile Separation	1373.8	549.9	7.585

ITALY 352 kg



AGILE (Astro-rivelatore Gamma Immagini Leggero) is a scientific mission dedicated to high-energy astrophysics operated by the Italian Space Agency (ASI) and scientifically developed in CNR and INFN laboratories of Italy.

The mission is to detect simultaneously gamma rays and hard X-rays using detectors viz. Super-AGILE (SA) and Gamma-Ray Imaging Detector (GRID) made of a Silicon Tracker and a Mini-Calorimeter. The Mini-Calorimeter is also capable of independently detect transient events. It can detect and image photons in the 30 MeV - 50 GeV and 10 keV - 40 keV energy bands. Agile will be orbiting in the near equatorial (2.5deg) orbit to take advantage of higher celestial activities in this field.

The satellite payload consists of detector having mainly Silicon tracker gamma-ray detector (ST), Mini-calorimeter detector (MCAL) & X-ray detector named Super-AGILE (SA) and Anti-Coincidence subsystem (AC). On detection of gamma ray burst, the information will be communicated to Orbcom constellation and message will be sent to scientists on the location of celestial activities for their further observation and studies using ground based instruments.

Agile having an overall size of satellite is 1689 x 2778 mm, will be powered by Li-Ion battery having 33 AH capacity. The battery will be charged using the fixed solar panel of 2100 x 1050 mm size. The nominal attitude of Agile is sun-pointing and for attitude pointing and control, star sensor, magnetometer and reaction wheels are used.

The ground station to be used is Malindi in Kenya and the communication is using S-band (2283.5 MHz down link and 2093.9 MHz uplink). Satellite is provided with two numbers of separation switches and bus will be ON immediately after separation from launch vehicle. The RF carriers will be ON just prior to contact with ground station. Interface with PSLV is through a Satellite Interface Ring weighing 3.8 kg having bolted connection with PSLV and this will be part of satellite on separation. The separation is by means of band clamp release and the required separation velocity of 1.2 m/s is provided by 4 numbers of springs.

ADVANCED AVIONICS MODULE

INDIA 185 kg

The AAM is a module consisting of the next generation avionic packages viz, Advanced Mission Computers (AMC) based NGC system, Advanced Inertial Navigation & Telemetry systems (AINS & ATS) that will become the prime avionic systems in the future.

The availability of excess payload capability in PSLV C8 has mooted the idea of flight qualifying these packages before inducting them into the main stream. The performance of these packages will be compared with the existing flight packages. This will help assess the package performance and incorporate suitable improvements before actually inducting these systems as the prime avionic systems in the future missions.

AAM UNDERGOING CHECKS

Though AAM is similar to a satellite flying in PSLV, it will not be separated from the spent stage. PSLV payload capability will improve by around 25 kg, once these packages are inducted into the operational phase.

The major highlight of AAM is the use of a ASIC based Computer with a 16 bit CPU called Vikram 1601, designed by VSSC, with operating frequency of 30 MHz. The AAM includes an improved version of the existing guidance package and advanced inertial system with state of the art gyros.

C8 LAUNCH CAMPAIGN ACTIVITIES

CBS + NES AT SLP

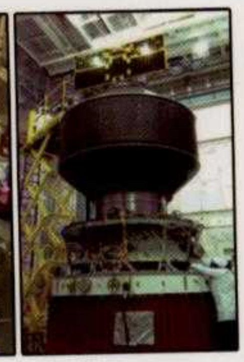
FIRST STAGE

SECOND STAGE

THIRD STAGE

FOURTH STAGE

AAM MOUNTED ON PLA



AGILE MOUNTED ON DLA

OPERATIONAL FLIGHTS

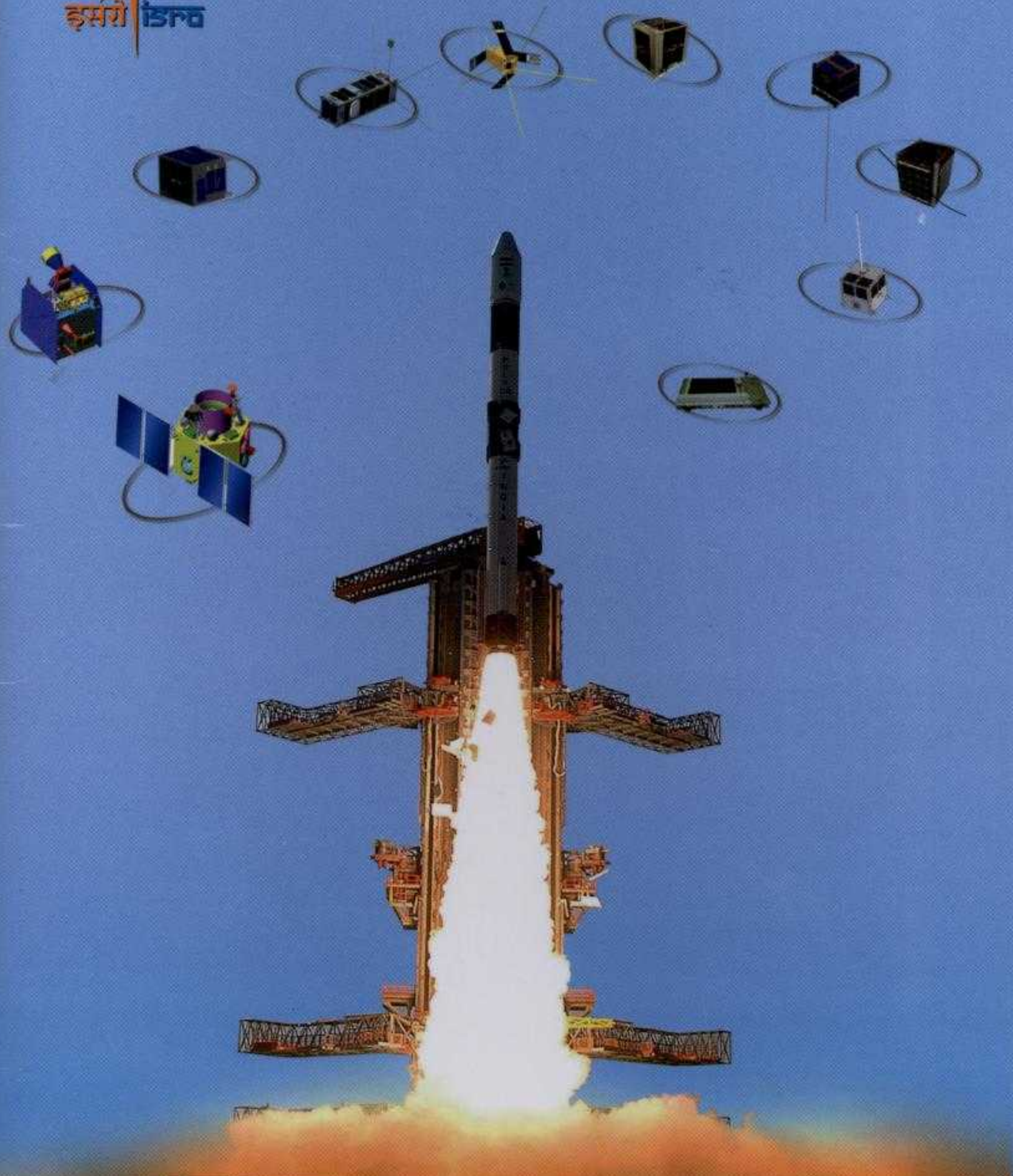
PSLV-C1	29 September 1997	IRS-1D
PSLV-C2	26 May 1999	IRS-P4, KITSAT, TUBSAT
PSLV-C3	22 October 2001	TES, PROBA, BIRD
PSLV-C4	12 September 2002	KALPANA-1
PSLV-C5	17 October 2003	IRS-P6
PSLV-C6	5 May 2005	IRS-P5, HAMSAT
PSLV-C7	10 January 2007	CARTOSAT-2, SRE LAPAN TUBSAT, NANO PEHUENSAT

PUBLISHED BY : DOCUMENTATION SECTION, PSLV PROJECT, VSSC, VALIAMALA, TRIVANDRUM

PRINTED AT : ST. JOSEPH's PRESS, TRIVANDRUM

design : ss vinod / pslv project

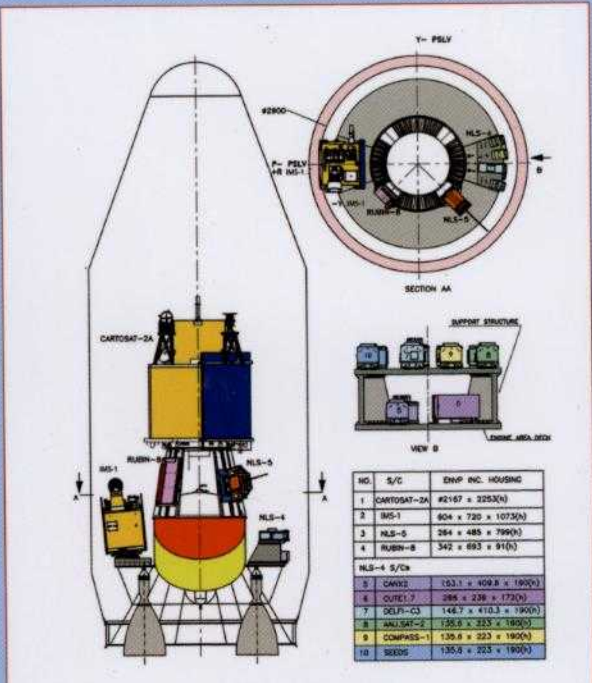
INDIAN SPACE RESEARCH ORGANISATION



PSLV C9/ CARTOSAT 2A/ IMS-1 MISSION

PSLV C9 MISSION

PSLV-C9 is the tenth operational flight of PSLV carrying ten satellites. This will be the first mission to employ a core alone vehicle to launch a satellite in SSPO orbit. The launch will orbit Cartosat-2A, IMS-1, six nos. of NLS-4 satellites, one no. of NLS-5 satellite and Rubin-8 into a circular SSPO orbit. While the Cartosat-2A and IMS-1 use the conventional Band clamp and IBL-298 separation systems respectively, the NLS-4 and NLS-5 satellite use their own separation system (called XPODs & Cute SS) for which the command goes from PSLV EB. Rubin-8 will not separate and will orbit along with the spent PS4 stage.



PSLV-C9 PAYLOAD ACCOMMODATION

Mission Specification

Orbit	:	635 km SSPO
Inclination	:	97.93 deg
Launch Time	:	09:23:51 hrs IST
Launch window	:	-0/+10 min
Launch Pad	:	Second Launch Pad
Launch Azimuth	:	140 deg

VEHIICLE

Overall height	-	44.4m
Lift-off mass	-	228 ton
First stage	-	PS1 (S139) HTPB Solid Propellant
Second stage	-	PS2 (PL40) UH25 + N_2O_4 Liquid Propellant
Third stage	-	HPS3 (S7) HTPB Solid Propellant
Fourth stage	-	PS4 (L1.6) MMH+Mon3 Liquid Propellant

The vehicle configuration for PSLV-C9 Mission remains same as PSLV-C10 except for the changes mentioned below

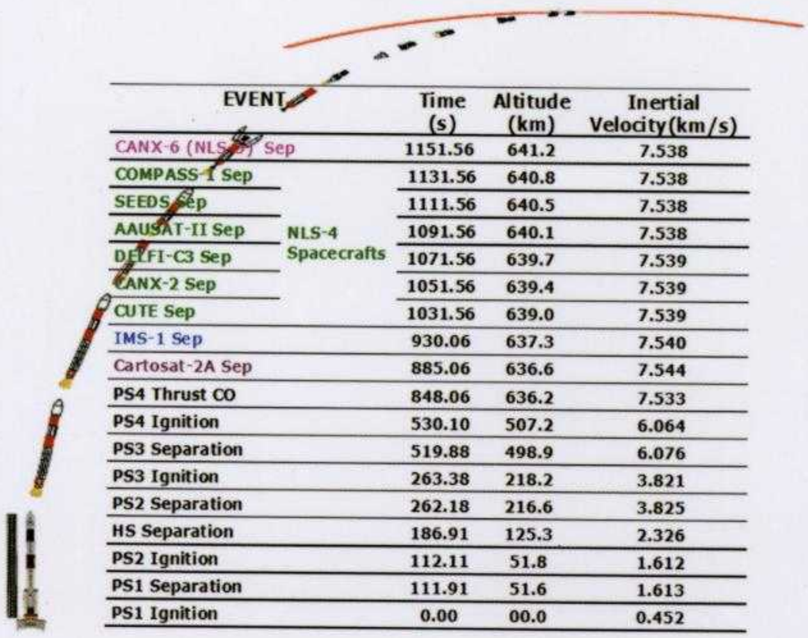
Major changes from PSLV C10

- Euler angle based guidance computation as in PSLV-C7
- Vehicle anchoring system as in C8
- Introduction of RCV in PS2 N_2O_4 MEV command line to prevent N depletion
- Use of 1040mm height PLA for the first time
- 10 satellites in a single mission
- Two tier mounting configuration for NLS-4 satellites on EB deck
- Mounting of Rubin-8 and NLS-5 on PLA
- Introduction of sequencer for separating NLS-4/5 satellites
- Use of the 110mm thick PPL deck for mounting IMS-1
- Flight qualification of IAMA and MEMS based acoustic sensors (IMAS)

Operational Flights

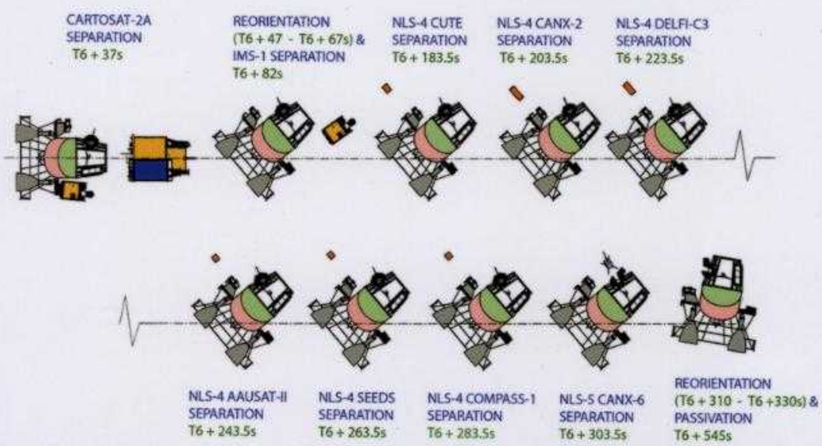
PSLV-C1	29 September 1997	IRS-1D
PSLV-C2	26 May 1999	IRS-P4, KITSAT, TUBSAT
PSLV-C3	22 October 2001	TES, PROBA, BIRD
PSLV-C4	12 September 2002	KALPANA-1
PSLV-C5	17 October 2003	IRS-P6
PSLV-C6	5 May 2005	IRS-P5, HAMSAT
PSLV-C7	10 January 2007	CARTOSAT-2, SRE, LAPAN TUBSAT, NANO PEHUENSAT
PSLV-C8	23 April 2007	AGILE
PSLV-C10	21 January 2008	POLARIS

Flight Profile



EVENT		Time (s)	Altitude (km)	Inertial Velocity(km/s)
CANX-6 (NLS-5) Sep		1151.56	641.2	7.538
COMPASS-1 Sep	NLS-4 Spacecrafts	1131.56	640.8	7.538
SEEDS Sep		1111.56	640.5	7.538
AAUSAT-II Sep		1091.56	640.1	7.538
DELFI-C3 Sep		1071.56	639.7	7.539
CANX-2 Sep		1051.56	639.4	7.539
CUTE Sep		1031.56	639.0	7.539
IMS-1 Sep		930.06	637.3	7.540
Cartosat-2A Sep		885.06	636.6	7.544
PS4 Thrust CO		848.06	636.2	7.533
PS4 Ignition		530.10	507.2	6.064
PS3 Separation		519.88	498.9	6.076
PS3 Ignition		263.38	218.2	3.821
PS2 Separation		262.18	216.6	3.825
HS Separation		186.91	125.3	2.326
PS2 Ignition		112.11	51.8	1.612
PS1 Separation		111.91	51.6	1.613
PS1 Ignition		0.00	00.0	0.452

Spacecraft Separation Sequence



Cartosat-2A (Mass: 686 kg)

Cartosat-2A mission is identical to that of Cartosat-2 mission. The main objective of the spacecraft is remote sensing for obtaining high resolution scene specific spot imageries from a highly agile platform carrying a single panchromatic camera operated in step & stare mode. The data products are used for cartographic applications at cadastral level.

The spacecraft is 3 axes stabilized for 2 nominal modes of operations namely sun pointing mode and imaging mode. The spacecraft is put in 635 km SSPO with 09.30 hrs ECT for 4 days revisit. Also it has capability for one time special orbit at 560 km for daily revisit. The spacecraft can be steered ± 26 deg across-track nominally for different modes of imaging.

IMS-1 (Mass: 83.4 kg)

IMS-1 is a Remote sensing mini satellite. The data from this satellite is planned to be used for Natural resources monitoring/management like agriculture, forest coverage and deforestation, urban infrastructure development, land use and waste land mapping, coastal features mapping, coral reef mapping and land slide studies. This project has been approved with the intention of providing access to remote sensing data to scientists and students of developing countries.

NLS-4

The NLS-4 is the designation of six satellites that will be mounted on the PPL deck at P+ side of EB. These satellites will be separated at an interval of every 20s using the separation system supplied along with the satellites. PSLV will issue the separation commands through a sequencer. All these satellites will be OFF during launch.

1. CanX-2 (Mass: 3.3 kg)

The CanX-2 is an experimental spacecraft built by the University of Toronto Institute of Aerospace Studies, Canada. The technologies to be tested include a novel cold gas propulsion system, custom radios, innovative attitude sensors and actuators and a commercial GPS receiver. The spacecraft will also perform GPS radio occultation experiment, network communication experiment and space materials experiment.

2. AAUSat-II (Mass: 1 kg)

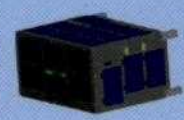
The AAUSat-II is built by Aalborg University at Denmark. Two scientific payloads are supported by the platform. An attitude control system with magnetorquers and momentum wheels which will be used to de-tumble and stabilize the spacecraft in three axes. The second payload is a Gamma- Ray Burst Detector.

3. COMPASS-1 (Mass: 1 kg)

COMPASS-1 is an experimental spacecraft built by the Aachen University of Applied Sciences in Germany. The mission of the spacecraft is to capture images from the earth and to validate the newly developed miniaturized spacecraft bus. The spacecraft includes 2 payloads namely a GPS receiver and a CMOS VGA camera system

4. CUTE 1.7 + APD II (Mass: 3.1 kg)

The CUTE 1.7+APD II is an experimental spacecraft built by the Tokyo Institute of Technology, Japan. The mission of the spacecraft is to demonstrate the use of a PDA (Personal Digital Assistant) based bus system for nano satellites and APD (Avarenche Photo-diode) sensor for astronomy observation.



5. Delfi-C3 (Mass: 3.1 kg)

The Delfi-C3 is an experimental spacecraft built by the Technical University Delft,The Netherlands. Delfi -C3 is a technology test-bed for 3 payloads viz. thin film solar cells, an autonomous wireless sun sensor, and an advanced transceiver. This spacecraft is without any battery as it is not operational in eclipse.

6. SEEDS (Mass: 1 kg)

SEEDS (Space Engineering Education Satellite) has been developed by the Nihon University, Japan. The main objective is to receive house keeping data from the spacecraft by CW signal. The other objectives are to receive the sensor data using FM packet downlink and to receive the sound data from SEEDS that is recorded in the digi-talker.

CanX-6 (NLS-5) (Mass: 6.8 kg)

CanX-6 is a technology demonstration spacecraft built by the Spaceflight Laboratory at the University of Toronto Institute for Aerospace Studies. The mission of the spacecraft is to perform a survey of VHF band centered on 162 MHz to be used as Maritime Identification System.

RUBIN-8 (Mass: 7 kg)

RUBIN-8 spacecraft is designed as non-separable attached payload, mounted on the Payload Adapter. The main purpose of the RUBIN-8 spacecraft is to test and develop a new space based receiver and data upload system for the maritime Automatic Identification System (AIS). This is a joint project of University of Applied Sciences and OHB system, Bremen, Germany.

Glimpses of PSLV C9 Launch Campaign

First Stage

PS2 Stacking

PS3-PS4 Module integration

Cartosat-2A testing at SP 1A

Satellite Assembly

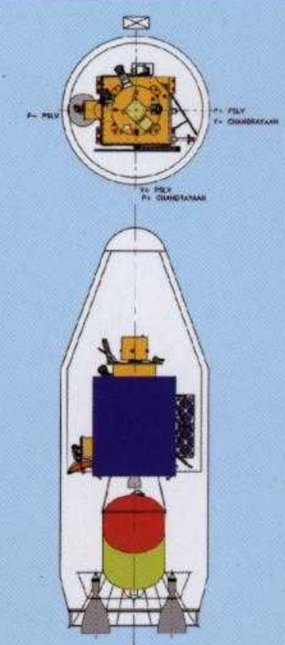
Heat Shield Closure

Published by: Documentation Section, PSLV Project, VSSC, Valiamala, Trivandrum
Printed at: St. Joseph's Press, Trivandrum

PSLV-C11
CHANDRAYAAN-1
MISSION

PSLV-C11/CHANDRAYAAN-1 MISSION

PSLV-C11 is the eleventh operational flight after three developmental flights. It is the first mission of PSLV using PSOM-XL, the upgraded strap-on booster. The newly introduced PSOM-XL is a stretched version of regular PSOM (longer by 3.4 m) carrying 3.3 tonnes of extra propellant in each. PSLV-XL will have a modified core base shroud. This variant can increase the PSLV payload capability from 1600 to 1750 kg in 600 km polar orbit.



Chandrayaan-1 accommodation in PSLV-C11 Heat Shield

The vehicle will place India's first lunar spacecraft, Chandrayaan-1 weighing 1380 kg in an Elliptical Transfer Orbit (ETO). The spacecraft is transferred to a highly elliptical orbit with apogee of 3,84,246 km by multiple apogee raising maneuvers. This is followed by mid course correction and subsequent Lunar Orbit Insertion (LOI) maneuver to capture Moon's polar orbit in 500 x 7500 km. Subsequent in-plane maneuver will place Chandrayaan-1 in 100 km circular orbit around Moon.

PSLV-C11/Chandrayaan-1 marks ISRO's beginning in inter planetary missions.

MISSION SPECIFICATION

Orbit	:	255 x 22860 km elliptical (ETO)
Inclination	:	17.9°
Launch time	:	06:22 Hrs IST
Launch window	:	15 mins
Launch pad	:	Second Launch Pad
Launch azimuth	:	102°

VEHICLE

Overall height	44.5 m
Lift-off mass	320 ton
First stage	PS1 (S139 + PSOM-XL) HTPB Solid Propellant
Second stage	PS2 (PL40), UH25 + N_2O_4, Liquid Propellant
Third stage	HPS3, HTPB Solid Propellant
Fourth stage	PS4 (L2.5), MMH + MoN3 Liquid Propellant

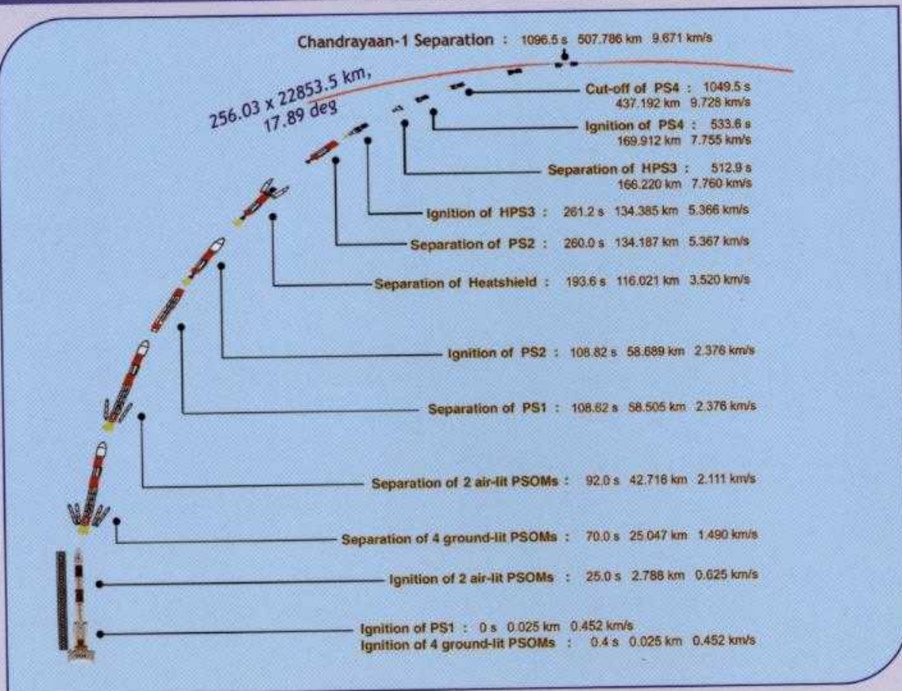
MAJOR CHANGES FROM PSLV-C9

- Introduction of PSOM-XL.
- PS1 Pressure sensing logic for early ignition of PSOM-XL.
- Sit on umbilical as a redundant measure for PS1 pressure sensing.
- PSOM-XL pressure monitoring scheme improved with redundant 'O' ring shaft seal.
- Improved wet life for pyro valves in RCS.
- CBS redesigned for PSLV-XL.
- TPS modified for 150°C limit.
- RMSA based ignition for PSOM-XL.
- Re-introduction of SITVC in Airlit PSOM.
- PS4 destruct system re-introduced.

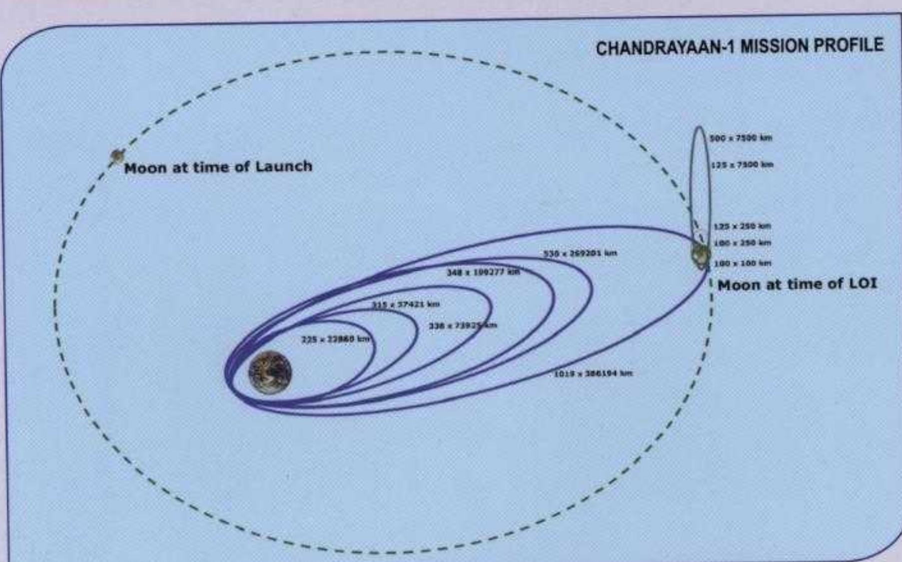
OPERATIONAL FLIGHTS

PSLV-C1	29 September 1997	IRS-1D
PSLV-C2	26 May 1999	IRS-P4, KITSAT, TUBSAT
PSLV-C3	22 October 2001	TES, PROBA, BIRD
PSLV-C4	12 September 2002	KALPANA-1
PSLV-C5	17 October 2003	IRS-P6
PSLV-C6	5 May 2005	IRS-P5, HAMSAT
PSLV-C7	10 January 2007	CARTOSAT-2, SRE, LAPAN TUBSAT, NANO PEHUEN SAT
PSLV-C8	23 April 2007	AGILE
PSLV-C10	21 January 2008	POLARIS
PSLV-C9	28 April 2008	CARTOSAT 2A, IMS-1 & 8 NANO SATELLITES

FLIGHT PROFILE



REACHING THE MOON



PAYLOADS IN CHANDRAYAAN-1

Terrain Mapping Camera (TMC)

TMC is aimed to map topography in both near and far side of the Moon and prepare a 3-dimensional atlas with high spatial and altitude resolution. It will image in the panchromatic spectral region of 0.5 to 0.85 μm with a spatial/ ground resolution of 5m, 10 bit quantization and swath coverage of 20 km.

Dimension: 370 x 220 x 414 mm. TMC is developed by ISRO and weighs 7 kg.

Hyper Spectral Imager (HySI)

HySI is aimed to obtain spectroscopic data for mineralogical mapping of the lunar surface. This data will help in studying the mineral composition of the lunar surface and in understanding the mineralogical composition of Moon's interior.

Dimension: 275 x 255 x 205 mm. HySI payload weighing 4 kg is developed by ISRO.

Lunar Laser Ranging Instrument (LLRI)

LLRI is aimed to prepare the altimetric map of the Moon which will help in studying the morphology of large basins and other lunar features, study stress, strain and flexural properties of the lithosphere. This when coupled with gravity studies would provide the density distribution of the crust.

LLRI is developed by ISRO and weighs 10 kg.

High Energy X-ray Spectrometer (HEX)

HEX covers the hard X-ray region from about 30 keV to about 250 keV. This is the first experiment to carry out spectral studies of planetary surface at hard X-ray energies using good energy resolution detectors. It is designed primarily to study emission in the above energy range due to radioactive decay of the ^{238}U and ^{232}Th in the lunar surface region.

HEX is developed by ISRO and has a mass of 16 kg.

Moon Impact Probe (MIP)

MIP will ride piggyback on the top deck of the main orbiter and will be released at a predetermined time after the orbiter reaches the final 100 km orbit to impact at a pre-selected location. This will help in design, development and demonstration of technologies required for impacting a probe at a desired location on the Moon.

Dimension: 375 x 375 x 470 mm. MIP weighing 32 kg is developed by Vikram Sarabhai Space Centre, ISRO.

Chandrayaan-1 X-ray Spectrometer (C1XS)

C1XS is aimed to carry out high quality X-ray spectroscopic mapping of the Moon. C1XS would use X-ray fluorescence technique (1.0-10 keV) for measuring elemental abundance of Mg, Al, Si, Ca, Fe, Ti distributed over the surface of the Moon.

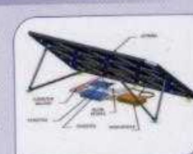
C1XS is realized through ESA with collaboration between Rutherford Appleton Laboratory, UK and ISRO Satellite Centre.

Near-IR Spectrometer (SIR-2)

SIR-2 will address the surface-related aspects of lunar science by analyzing in unprecedented detail the lunar surface in various geological/ mineralogical and topographical units. It will help to study the vertical distribution of crustal material, investigate the process of basin, maria and crater formation on the Moon.

SIR-2 is developed by the Max-Plank-Institute for Solar System Science, through the Max-Plank Society, Germany and ESA.

Miniature Synthetic Aperture Radar (MiniSAR)



MiniSAR is an onboard radar mapper that will allow viewing of all permanently shadowed areas on the Moon, regardless of whether sunlight is available or the angle is not satisfactory.

MiniSAR is from Applied Physics Laboratory, Johns Hopkins University and Naval Air Warfare Centre, USA through NASA.

Sub keV Atom Reflecting Analyser (SARA)

SARA will image the Moon surface using low energy neutral atoms in the energy range 10 eV-2 keV. It will help in the imaging of the Moon's surface composition including the permanently shadowed areas, solar wind surface interaction and the lunar surface magnetic anomalies studies of space weathering.

SARA is realized through ESA, in collaboration with Swedish Institute of Space Physics, Sweden and Space Physics Laboratory, Vikram Sarabhai Space Centre, ISRO and weighs 4 kg.

Radiation Dose Monitor Experiment (RADOM)

RADOM will qualitatively and quantitatively characterize, in terms of particle flux, dose rate and deposited energy spectrum, the radiation environment in near Moon space.

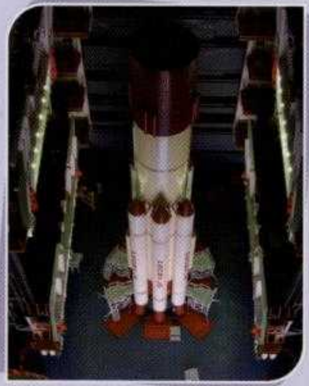
RADOM is from Bulgarian Academy of Sciences.

Moon Mineralogy Mapper (M3)

The primary Science goal of M3 is to characterize and map lunar surface mineralogy in the context of lunar geologic evolution. This translates into several sub-topics relating to understanding the highland crust, basaltic volcanism, impact craters, and potential volatiles.

M3 payload weighing 7 kg is from Brown University and Jet Propulsion Laboratory, USA through NASA.

PSLV-C11 LAUNCH CAMPAIGN



PS1 at VAB

PS2 Assembly

PS3-PS4 Moduling

EB Testing at VAB

Satellite Assembly

Heat Shield Closure

Published by: Documentation & Library Cell, MVIT/PSLV, VSSC, Thiruvananthapuram

PSLV - C14 /OCEANSAT-2 MISSION

Indian Space Research Organisation

PSLV MISSIONS IN CORE ALONE CONFIGURATION

PSLV-C8/Agile

PSLV-C10/Polaris

PSLV-C9/Cartosat-2A

PSLV-C12/ Risat-2

PSLV-C14/OCEANSAT-2 MISSION

PSLV-C14, the 16th flight of PSLV will inject Oceansat-2 and six nano-satellites into 724.7 km circular SSPO. Core Alone configuration of the vehicle with PS4 L2.5 stage is used to place the satellites in orbit.

MISSION SPECIFICATIONS

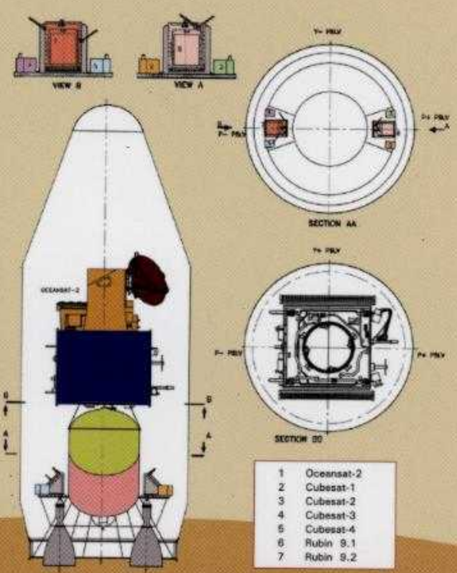
Orbit	: Sun Synchronous Polar Orbit (SSPO)
Altitude	: 724.7 ± 20 km
Inclination	: 98.28 ± 0.2 degree
Launch time	: 11.51 Hrs (IST)
Launch window	: -0/+15 min
Launch azimuth	: 140 degree

VEHICLE

Overall height	: 44.4 m
Lift-off mass	: 228 t
First stage	: PS1(S139), HTPB solid propellant
Second stage	: PS2(PL40), UH25+N_2O_4 liquid propellant
Third stage	: HPS3, HTPB solid propellant
Fourth stage	: PS4(L2.5), MMH+MON3 liquid propellant

Changes and New elements in C-14 Vehicle

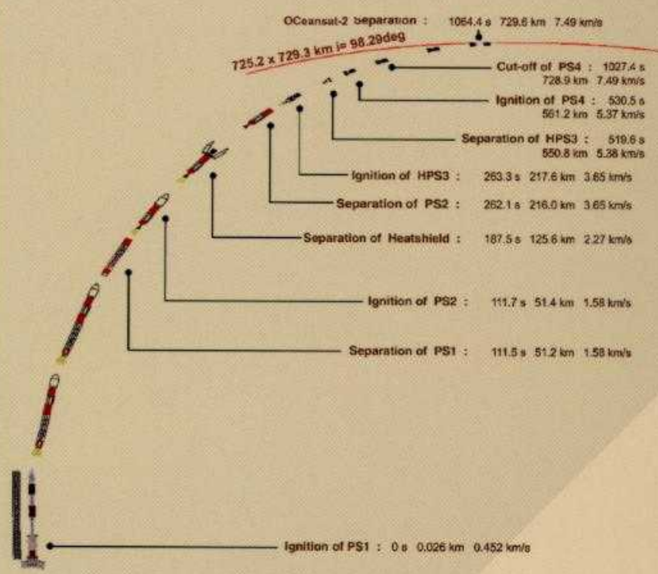
- PS4 to use L2.5 stage
- First time use of ECI frame and Quaternion based guidance computation for SSPO mission
- Introduction of 45° inclined auxiliary decks to mount Rubin-9.1& Rubin-9.2 nano-satellites on EB
- Cubesats are separated using a separation system, Single Picosatellite Launcher (SPL) supplied by the user
- 'O' ring seal configuration for PS1 motor pressure transducer joints



Spacecraft accommodation in C14

FLIGHT SEQUENCE

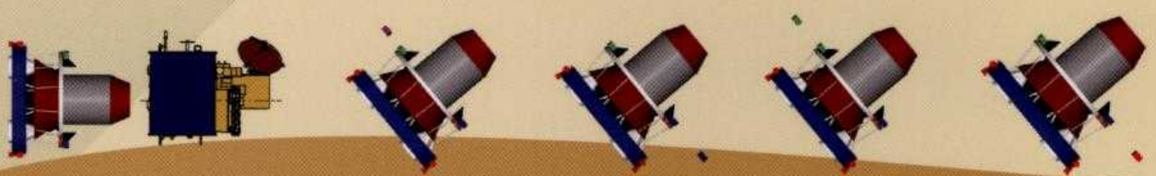
The flight sequence given below highlights the planned time, altitude and velocity at critical events. Some of the events are decided onboard and the actual time of occurrence can vary marginally.



PSLV-C14 flight profile

EVENTS	PSLV-C14 MISSION		
	Time(s)	Altitude (km)	Inertial Velocity (m/s)
RCT Ignition	-3.00	0.02619	451.89
PS1 Ignition	0.00	0.02619	451.89
PS1 Tail-off (RTD-T2)	106.52	46.23	1603.78
PS1 Separation	111.52	51.18	1581.97
PS2 Ignition	111.72	51.38	1580.96
Heat shield Separation	187.52	125.63	2273.14
C L G Initiation	192.52	130.94	2341.31
PS2 shut-off (RTD-T3)	259.14	211.80	3638.25
PS2 Separation	262.14	215.99	3652.05
PS3 Ignition	263.34	217.66	3647.87
PS3 burn out (RTD-T4)	385.58	382.59	5631.59
PS3 Séparation	519.58	550.86	5383.65
PS4 Ignition (RTD-T5)	530.52	561.22	5367.68
PS4 Cut-off (RTD T6)	1027.4	728.96	7485.10
OCEANSAT-2 Separation	1064.4	729.68	7490.47
CUBESAT-1 Separation	1104.4	730.42	7490.15
CUBESAT-3 Separation	1124.4	730.8	7489.98
CUBESAT-2 Separation	1164.4	731.58	7489.63
CUBESAT-4 Separation	1184.4	731.98	7489.46

Separation sequence of spacecrafts in PSLV-C14 mission



T6 + 37s Oceansat-2 Separation

T6 + 77s Cubesat-1 Separation

T6 + 97s Cubesat-3 Separation

T6 + 137s Cubesat-2 Separation

T6 + 157s Cubesat-4 Separation

OCEANSAT-2

Oceansat-2 spacecraft weighing 956 kg will provide continuation of services of Oceansat-1 (IRS-P4 launched by PSLV-C2 on 26 May, 1999) with enhanced capabilities & increased application areas. The spacecraft, built by ISRO Satellite Centre, Bangalore will fly Ocean Colour Monitor (OCM), Ku-band Scatterometer and Radio Occultation Sounder for Atmosphere (ROSA). During operational phase of the spacecraft, Scatterometer and ROSA payloads are continuously ON and OCM will be switched ON during sun-lit passes over oceans as per user requirements.

The mission objectives of OCEANSAT-2 are the following:

- To design, develop, launch and operate state of-the art three axes stabilized spacecraft carrying the Ocean Colour Monitor, Ku-band Scatterometer and the dual frequency Radio Occultation Sounder for Atmospheric studies with a mission life of 5 years
- To develop algorithms for retrieval of parameters such as wind vector from Scatterometer; chlorophyll, suspended sediments, aerosol optical depth from Ocean Colour Monitor; characterise the lower atmosphere and the ionosphere using ROSA; and to supply data products operationally to the user community
- To promote newer applications in the areas of ocean and atmospheric science

OCM is a multi-spectral optical camera, that provides ocean colour data with repetivity of two days. It provides a ground IFOV of 360 m in across track and 246 m in along track directions covering a swath of 1420 km . Provision exists for onboard calibration of this payload.

The Ku band pencil beam scatterometer is an active microwave sensor that provides a ground resolution cell of size 50x 50 km for measurement of wind speed and direction. It has two modes of operation-raw data mode and processed data mode. Raw data mode will be used only during the initial phase for validation of processed data.

The ROSA is a GPS Receiver for atmospheric sounding by radio occultation. The GPS receiver determines position, velocity and time using GPS signals. It provides real-time navigation data with conventional accuracy. Additionally this payload derives the atmospheric parameters (Temperature, humidity and pressure) through RF signals from the 'rising' GPS satellites near Earth's horizon through its occultation antenna & from the excess phase delay and Doppler measurement. The ROSA instrument processes the received GPS signals in both the L1 (1575.42 MHz) and L2 (1227.6 MHz) frequency bands.

Physical Characteristics of OCEANSAT-2	
Mass	: 956 kg
Shape	: cuboidal
Overall dimensions in launch configuration	: 2445x1972x2900(h)
End to end length in deployed mode	: 11400 mm
Solar panel	: 2 wings of 3 panels each
Power	: 1140 watts EOL average

OCEANSAT-2 DEPLOYED CONFIGURATION

PASSENGER PAYLOADS

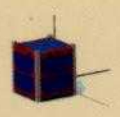
CUBESAT SATELLITES

The four CUBESATs are educational satellites from European universities, each weighing around one kg and developed to perform technology demonstration in space. The satellites are housed inside individual SPL weighing one kg.

CUBESAT-1 /UWE-2 (Universität Würzburg, Germany)

Mission objectives:

- Demonstration of a newly developed Attitude Determination and Control system (ADCS)
- Technology demonstration of a GPS on Cubesat



CUBESAT-1

CUBESAT-2/BeeSat (Technische Universität Berlin, Germany)

Mission objectives:

- On-orbit verification of newly developed micro reaction wheels for picosatellite applications
- Demonstration of the use of coin sized micro reaction wheels for attitude control of picosatellites

CUBESAT-2

CUBESAT-3/ITU-pSAT1 (Istanbul Technical University, Turkey)

Mission objectives:

- To examine the performance of an on-board passive stability system using a magnet
- To download photographs taken using a camera with a resolution of 640X480 pixels

CUBESAT-3

CUBESAT-4/SwissCube (Ecole Polytechnique Fédéral de Lausanne, Switzerland)

Mission objectives:

- To take optical measurements and characterise the airglow intensity over selected latitudes and longitudes
- To demonstrate the measurement of airglow intensity using off-the shelf detector and its validation

CUBESAT-4

RUBIN-9

RUBIN-9 consists of two S/Cs Rubin 9.1 and Rubin 9.2 weighing 8 kg each and will primarily be used for the Automatic Identification System (AIS) for Maritime applications. These are non-separable payloads that are mounted at an angle of 45 deg to the PSLV EB deck.

Rubin9.1 is developed by Luxspace, Luxembourg and has a mission objective of providing an insight into the issue of message collisions that limit detection in areas of dense shipping.

Rubin-9.1

Rubin-9.2

The main purpose of the R9.2 spacecraft is to test and qualify nano technologies from Angstrom company, Sweden and to continue space based maritime Automatic Identification System (AIS) receiver experiments (started with Rubin-7 and Rubin-8 missions).

R9.2 is similar to the Rubin-8 launched on PSLV in April 2008.

PRE LAUNCH OPERATIONS


CBS assembly


PS1 stage at MST


PS2 receipt at MST


PS3-PS4 Moduling


Vehicle ready to receive spacecrafts


Oceansat-2 testing


Nano satellites after testing


Satellites integrated to vehicle


HS closure

Published by: Documentation and Information Services-LV Projects, VSSC, Thiruvananthapuram
Printed at: St. Joseph's Press, Thiruvananthapuram

OCEANSAT-2

Oceansat-2 is India's second satellite built for the study of the oceans as well as the interaction of oceans and the atmosphere to facilitate climatic studies. With the goal of providing continuity of services available from Oceansat-1 (IRS-P4) as well as to facilitate new applications, the 960 kg Oceansat-2 is launched into a polar Sun Synchronous Orbit (SSO) of 720 km height by India's workhorse launch vehicle PSLV during its sixteenth mission. In this mission, designated as PSLV-C14, six nano satellites are also carried by PSLV along with Oceansat-2 as auxiliary payloads to orbit. Data sent by the three payloads of Oceansat-2 – Ocean Colour Monitor (OCM), Ku-band Pencil Beam Scatterometer and Radio Occultation Sounder for Atmospheric Studies (ROSA) – are received at National Remote Sensing Centre (NRSC) of ISRO. ROSA is built by Italian Space Agency (ASI).

Oceans cover about 70% of the Earth's surface. Considering the importance of oceans as a source of food for humans as well as their important role in shaping the Earth's weather and climate, and their influence on global energy balance and biological life cycle, study of oceans becomes very important. In this context, Oceansat-2 mission acquires added significance.

Oceansat-2: The Satellite

Oceansat-2 is the sixteenth remote sensing satellite of India. The state-of-the-art Oceansat-2 weighs 960 kg at lift-off and has the shape of a cuboid with two solar panels projecting from its sides. The satellite's CFRP structure facilitates mounting of payloads while its thermal subsystem consisting of many passive materials and active gadgets helps maintain the spacecraft's temperature within safe limits. The Oceansat-2's mechanisms subsystem takes care of the deployment of its two solar panels as well as the release of OCM and Scatterometer from their 'hold down position'. It also facilitates the tilting of OCM payload to avoid sun glint. The satellite's solar panels generate electrical power during sunlit period besides charging the batteries, which supply electrical power when the satellite is in eclipse.

Ku-band Scatterometer

The Telemetry, Tracking and Command subsystem of Oceansat-2 works in S-band and its payload data is relayed through X-band. The satellite has a 64 GB solid state recorder to store the imagery for later read out. A host of Earth and Sun Sensors as well as gyroscopes provide the directional reference for its processor based Attitude and Orbit Control System to properly orient the spacecraft and provide sufficient stability during various phases of the mission, especially during imaging. Four Reaction Wheels and mono propellant Hydrazine thrusters are used as actuators to control its orientation. Thusters are also used for the satellite's orbit control.

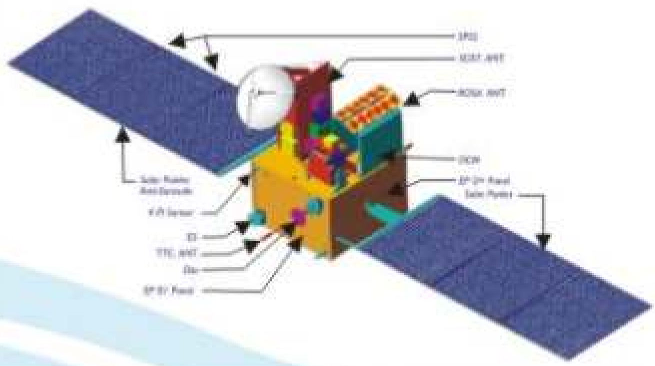
Oceansat-2 being prepared for prelaunch tests

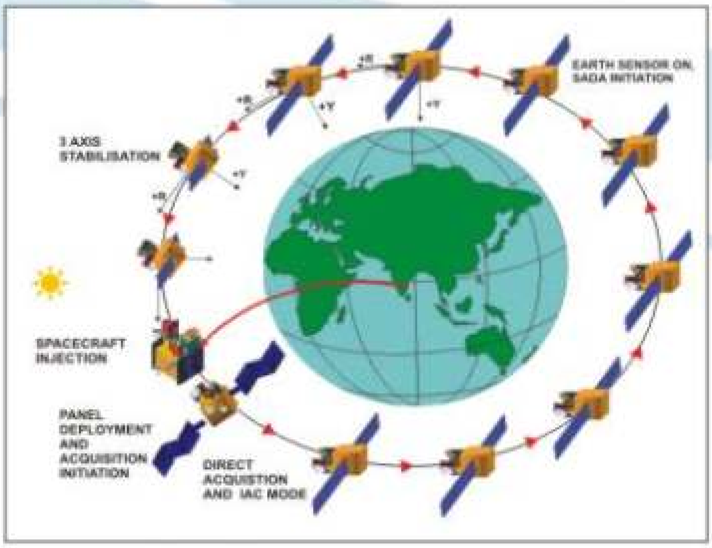
Readying Oceansat-2 for Thermo-vacuum test

The eight band Ocean Colour Monitor carried by Oceansat-2 images a swath (strip of land or ocean) of 1420 km with a resolution of 360 metre and works in the Visible and Near Infrared region of the electromagnetic spectrum. The Ku-band Scatterometer with a 1m diameter antenna rotating at 20 rpm and generating two beams, works at a frequency of 13.515 Ghz. The Scatterometer covers a swath of 1400 km and operates continuously. ROSA is a GPS Receiver for atmospheric sounding by radio occultation. It determines position, velocity and time using GPS signals. Besides providing real-time navigation data with conventional accuracy, ROSA receives RF signals from the 'rising' GPS satellites near Earth's horizon through its occultation antenna and from the excess phase delay and Doppler measurements made by this payload, vertical profiles of atmospheric parameters (density, refractivity, temperature, humidity and pressure) will be derived upto an altitude of about 30 km.

Oceansat-2 at a glance:

Structure	:	CFRP Cylinder and Aluminium Honeycomb Panels
Thermal	:	Paints, MLI blankets, Optical Solar Reflectors, Heaters and temperature controllers
Mechanisms	:	Solar Panels deployment, OCM and Scatterometer hold down release and OCM tilt
Power	:	Solar panels of 15 sq m area generating 1360 W, two 24 Ah Ni-Cd batteries
TTC	:	S-band
P/L Data transmission	:	X-band
On-board storage	:	Solid State Recorder of 64 GB capacity
Attitude and Orbit Control System	:	Earth sensors and Sun sensors, Magnetometers, Gyroscopes, mono propellant Hydrazine thrusters, Reaction wheels and Magnetic Torquers
Reaction Control System	:	100 kg of Hydrazine





Mission Profile of Oceansat-2

Orbit details of Oceansat-2:

Type	:	Near polar sun-synchronous
Altitude	:	720 km
Inclination	:	98.28 Deg
Period	:	99.31 mts.
Local time of equator crossing	:	12 noon ± 10 minutes
Repetevity cycle	:	2 days
Mission life	:	5 years

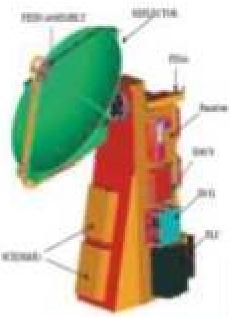
OCM at a glance:

Resolution at nadir	:	360m x 236m From 720 km
SWATH	:	1420 km
Repetitivity	:	2 Days
No. Of Bands	:	8 (Visible and Near Infrared)
Spectral bands (nm)	:	412, 443, 490, 510, 555, 620, 740, 865
Along track steering	:	±20°
Mass	:	76 kg

OCM

Scatterometer at a glance:

Altitude	:	720 km
Operating Frequency	:	13.5156 GHz (Ku-band)
Wind Vector Cell size	:	50 km X 50 km
Antenna	:	Parabola of 1.0 m dia
Scanning Rate	:	20.5 rpm
Swath (Qualified)	:	1400 km
Wind Speed Range	:	4 to 24 m/s
Wind Speed Accuracy	:	2 m/sec
Wind Direction & Accuracy	:	20 deg



Scatterometer

ROSA at a Glance:

Hardware	:	Radio Occultation Antenna, Precise Orbit Determination (POD) antenna and receiver
Frequencies of operation	:	L1 1560-1590 MHz L2 1212-1242 MHz
Horizontal resolution	:	Less than 300 kms for temperature and humidity
Vertical resolution	:	0.3 km (lower troposphere) 1-3 km (upper trophosphere)
Accuracy	:	Less than 1.0 K for temperature 10% or 0.2g/kg for humidity

ROSA

Oceansat-2

PSLV-C14: The Launcher

Positioning of nozzle end segment of PSLV-C14 first stage

ISRO's workhorse launch vehicle PSLV is chosen to launch Oceansat-2 during its PSLV-C14 mission, which is its sixteenth. During Sept 1993-April 2009 period, PSLV was launched fifteen times and scored 14 consecutive successes. In this 16 year period, PSLV has repeatedly proved its reliability and versatility by launching satellites into polar Sun Synhcronous, Gesoynchronous Transfer, Low Earth and Highly Elliptical orbits. Of the 32 satellites launched by PSLV so far, 16 have been Indian and the rest being satellites from abroad. During many of its missions, PSLV has launched multiple satellites into orbit with the maximum number being 10 during PSLV-C9 mission in April 2008.

During PSLV-C14 mission, PSLV will carry six nano satellites - Cubesat 1, 2, 3 and 4 as well as Rubin 9.1 and 9.2 - as auxiliary payloads along with Oceansat-2. The weight of these nano satellites is in 2-8 kg range. Oceansat-2 and the six auxiliary payloads are scheduled to be carried into a polar Sun Synchronous Orbit of 720 km height inclined at an angle of 98.28 deg to the equator.

The auxiliary payloads of PSLV-C14 are educational satellites from European Universities and are intended to test new technologies. After the separation of Oceansat-2 from PSLV-C14, the four cubesats will be separated, while Rubin 9.1 and 9.2 remain permanently attached to the upper stage.

Second stage of PSLV-C14 being lifted during vehicle integration

One of the nanosatellites undergoing preluanch tests

The 44.4 metre (147 ft) tall PSLV-C14 weighs 230 tons at lift-off. PSLV-C14 is the 'core alone' version of PSLV which is almost the same as PSLV 'standard configuration' except for the 'strap-on motors'. Six such 'strap-ons' surround the first stage of PSLV 'standard confirguration', but are absent in 'core alone' version. PSLV-C14 is the fifth 'core alone' mission of PSLV.

PSLV-C14 has four stages using solid and liquid propulsion systems alternately. The first stage, carrying 139 tonne of propellant, is one of the largest solid propellant boosters in the world. The second stage carries 41.5 tonne of liquid propellant. The third stage uses 7.6 tonne of solid propellant and the fourth has a twin engine configuration with 2.5 tonne of liquid propellant (compared to 2 tonne in the previous mission - PSLV-C12).

PSLV was originally designed to place 1,000 Kg class of India's remote sensing satellites into a 900 km polar Sun Synchronous Orbit (SSO). The payload capability of PSLV has been successively enhanced and in its ninth flight, PSLV-C6, in May 2005, the vehicle launched two payloads – 1,560 kg CARTOSAT-1 and 42 kg HAMSAT into a 620 km SSO. And, in its thirteenth flight, PSLV-C9, the vehicle launched ten payloads – 680 kg CARTOSAT-2A, 83 kg Indian Mini

PSLV-C14 Stages at a Glance

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core (PS1)	PS2	PS3	PS4
Propellant	Solid HTPB Based	Liquid UH25 +N_2O_4	Solid HTPB Based	Liquid MM H+MON-3
Mass (Tonne)	138.0	41.0	7.6	2.5
Max Thrust (kN)	4817	799	238	7.3x2
Burn Time (Sec)	101	147	112	497
Stage Dia (m)	2.8	2.8	2.0	2.8
Stage Length (m)	20	12.8	3.6	2.6
Control	SITVC for Pitch & Yaw, Reaction Control Thrusters for Roll	Engine Gimbal for Pitch & Yaw, Hot Gas Reaction Control Motor for Roll Control	Flex Nozzle for Pitch & Yaw, PS 4 RCS for Roll	Engine Gimbal for Pitch, Yaw & Roll, on-off RCS for Coast Phase Control

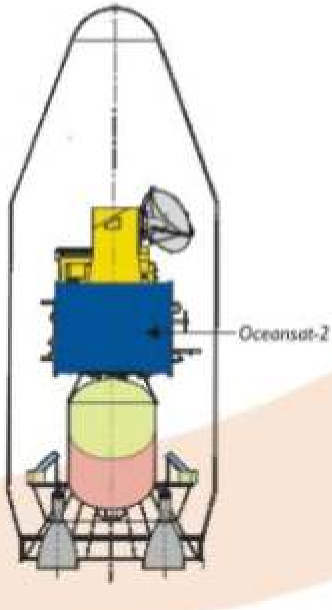
Satellite (IMS-1) and eight nano satellites from abroad. Later, the uprated version of the vehicle, PSLV-C11, launched India's first spacecraft to moon, Chandrayaan-1, into a highly elliptical orbit around the earth.

The improvement in the capability of PSLV over successive flights has been achieved through several means. They include increased propellant loading in the stage motors and the strap-ons, employing composite material for the satellite mounting structure and changing the sequence of firing of the strap-on motors.

The 3.2 metre diameter metallic bulbous payload fairing of PSLV-C14 protects the satellites during the atmospheric flight and it is discarded after the vehicle has cleared the dense atmosphere. PSLV employs a large number of auxiliary systems for stage separation, payload fairing separation and so on. It has sophisticated systems to control the vehicle and guide it through the predetermined trajectory.

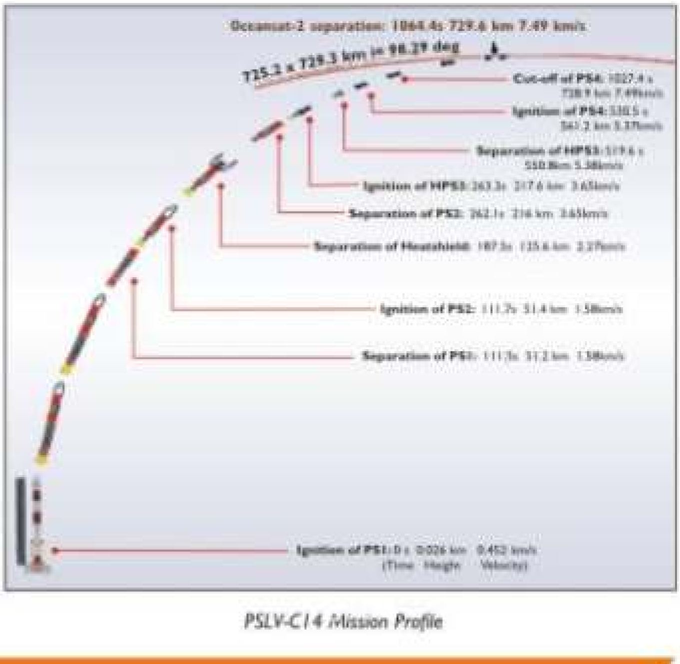
Readying the upper stages

Launch vehicle personnel working on PSLV-C14 fourth stage



Oceansat-2 in PSLV-C14 envelope

The vehicle performance is monitored through Telemetry and Tracking. With fourteen consecutively successful flights so far, PSLV has repeatedly proved itself as a reliable and versatile workhorse. It has demonstrated multiple satellite launch capability having launched sixteen satellites for international customers besides sixteen Indian payloads of which eleven were remote sensing satellites, others being a satellite for amateur radio communications, a recovery capsule (SRE-1), a meteorological (weather watching) satellite, one mooncraft and a university satellite. Though originally designed for launching payloads into polar Sun Synchronous Orbits, PSLV was used in September 2002 to launch ISRO's exclusive meteorological satellite, KALPANA-1, into a Geosynchronous Transfer Orbit (GTO) and thus proved its versatility. And in April 2007, the vehicle launched the Italian astronomical satellite AGILE into a Low Earth Orbit of 550 km height. More recently, the vehicle was also successfully used to launch a spacecraft for India's first mission to Moon, Chandrayaan-1, in 2008.



PSLV-C14 Mission Profile

Remote Sensing Data Applications

Agriculture

Today, imagery sent by the large constellation of Indian Remote Sensing satellites is being extensively used in various sectors of Indian economy including agriculture, rural development, water resources, urban planning, infrastructure development, marine resources, forestry, fishery, environmental monitoring and disaster management. Studies to examine the feasibility of using remote sensing data for various tasks began in the country as early as 1972 itself. Following this, analysis of imagery from Bhaskara as well as those from Landsat and SPOT satellites enabled Indian applications scientists to learn the technique of systematically interpreting them. Remote sensing satellite utilisation plan got a further fillip with the launch of IRS-1A in 1988, and during the 1990s, IRS data utilisation became institutionalised.

IRS imagery is regularly being used now for such important developmental tasks like crop acreage and production estimation, crop health monitoring, groundwater prospecting, wasteland mapping, forest cover assessment and forest fire detection, biodiversity characterisation, potential fishing zone identification, snow cover monitoring, coastal zone studies, coral and mangrove mapping, urban planning and pollution monitoring. Today, remote sensing data forms an important input in forecasting agricultural crop output. And, the success rate in digging bore wells has seen a substantial increase with the utilisation of remote sensing satellite data.

Water Resources

Environment

The accurate classification of wastelands, which has been done based on IRS data, leads to their reclamation and eventual utilisation for agricultural purposes. Similarly, forest cover assessment and forest fire detection are useful in managing our precious forest wealth and the associated biodiversity. This apart, pollution monitoring can help us prevent or mitigate environmental degradation. And, use of remote sensing satellite imagery can lead to orderly development of urban areas.

Soil

The launch of Indian remote sensing satellites of increased sophisitication with better spatial, spectral, temporal and radiometric resolution will enable more intense and detailed survey of India's natural resources, which is necessary for their efficient management. Today, remote sensing satellites of India provide data in the resolution range of 360 m to better than 1m. Together, they provide multispectral, hyperspectral, panchromatic as well as stereoscopic imagery. As of July 2009, India had a constellation of nine remote sensing satellites circling the Earth, mostly in polar Sun Synchronous Orbits of 550-820 km height. Imagery from some

of them is being marketed worldwide.

Specifically, data from IRS-P4 (Oceansat-1) is being used for various applications both within India as well as by international users. The most significant application areas of IRS-P4 data are advisories of Potential Fishing Zones (PFZ), Coastal water pollution and sedimentation monitoring, estimation of water vapour content in the atmosphere and the prediction of the onset of Monsoon. The advisories of PFZ helped in increasing catch per unit effort. The advisories contain information about distance, direction and depth of potential fishing zones.

PFZ forecast is sent to all major fishing harbours and fishing co-operatives free of cost by Indian National Centre for Ocean Information System (INCOIS), Ministry of Earth Sciences through local newspaper, radio, fax, telephone, digital display boards, website, etc. Impact of human induced activities like urban/industrial expansion, tourism, acquaculture and pollution on the coastal waters as well as pollutants like oil slicks and contaminants can be monitored using OCM data.

Similarly, data from Scatterometer can be utilised for important activities like numerical weather prediction / forecasting, ocean state forecasting, identification of cyclone and hurricane formation and monitoring their progress. Besides, PFZ identification can be improved by the assimilation of wind information provided by scatterometer with Chlorophyll concentration data from OCM as well as Sea Surface Temperature data. This apart, Scatterometer data facilitates monitoring of changes in polar Sea Ice. And, it serves as a data source for developing algorithms for the retrieval of geophysical parameters like wind vector and ocean colour from observed data. By blending of this data with data collected from other sources, ocean and atmospheric models can be developed.

In 2008, ISRO released an Announcement of Opportunity (AO) for utilisation of both OCM and Scatterometer data for global scientific community, in response to which 28 proposals were received from International users. In addition, Oceansat-2 Utilisation Programme for Indian users has also been launched.

Disaster Warning and Management

Geoscience

Forests

Ocean Applications

Remote Sensing Satellites of India

Sl No.	Name	Weight (Kg)	Orbit (Polar Sun Synchronous- in km)	Payload	Launch Date	Launch Vehicle	Launch Centre	Remarks
1	IRS-1A	980	904	LISS-1 LISS 2A & 2B	March17 1988	Vostok	Baikonur	
2	IRS-1B	980	904	LISS-1 LISS 2A & 2B	August 29 1991	Vostok	Baikonur	
3	IRS-1E	804	820	LISS - 1	Sept 20 1993	PSLV-D1	SDSC SHAR (Shriharikota)	Could not reach orbit
4	IRS-P2	850	820	LISS-2A & 2B	Oct 15 1994	PSLV-D2	SDSC SHAR	
5	IRS-1C	1100	820	PAN, LISS-3 & WiFS	Dec 28 1995	Molniya	Baikonur	
6	IRS-P3	900	820	WiFS, MOS & X-Ray	March 21 1996	PSLV-D3	SDSC SHAR	
7	IRS-1D	1250	740x820	LISS-3, PAN & WiFS	Sept 29 1997	PSLV-C1	SDSC SHAR	In service
8	Oceansat-1 (IRS-P4)	1050	720	OCM & MSMR	May 26 1999	PSLV-C2	SDSC SHAR	In service
9	TES	1108	560	PAN	Oct 22 2001	PSLV-C3	SDSC SHAR	In service
10	Resourcesat-1 (IRS-P6)	1360	817	LISS-3, LISS-4 & WiFS	Oct 17 2003	PSLC-C5	SDSC SHAR	In service
11	Cartosat-1 (IRS-P5)	1560	630	PAN Fore & PAN Aft	May 05 2005	PSLV-C6	SDSC SHAR	In service
12	Cartosat-2	650	630	PAN	Jan 10 2007	PSLV-C7	SDSC SHAR	In service
13	Cartosat-2A	690	630	PAN	April 28 2008	PSLV-C9	SDSC SHAR	In service
14	IMS-1	83	630	Mx & HySI	April 28 2008	PSLV-C9	SDSC SHAR	In service
15	RISAT-2	300	550 (medium inclination orbit)	Radar	April 20 2009	PSLV-C12	SDSC SHAR	In service

September 2009

INDIAN SPACE RESEARCH ORGANISATION
Publications & Public Relations, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore-560 231, India
Designed by Imagic Creatives, Bangalore. Printed at Print-O-Graph, Bangalore
www.isro.gov.in

PSLV-C15/CARTOSAT-2B Mission

INDIAN SPACE RESEARCH ORGANISATION

Vehicle

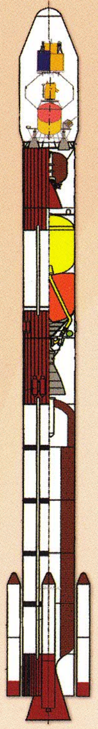
PSLV Core Alone Variant with L2.5 as upper stage

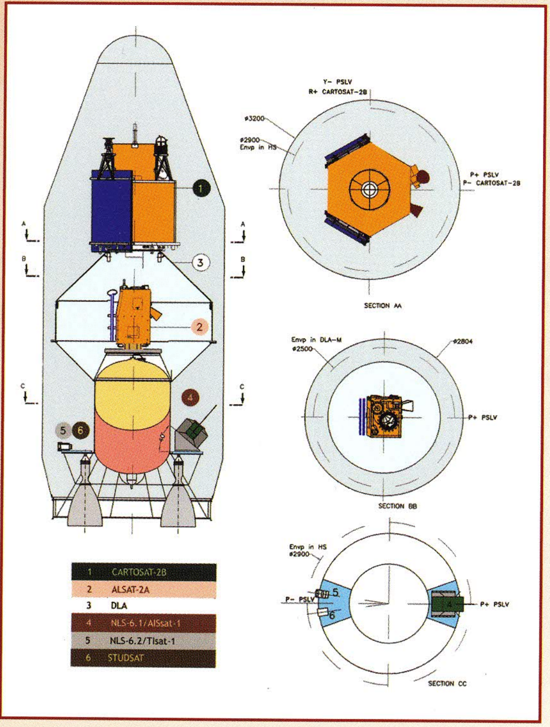
Mission Specification

Orbit (Osculating)	:	637 km circular SSPO
Inclination	:	98.1 deg
Launch Time	:	09:22 hrs IST
Launch Window	:	-0/+15 min
Launch Pad	:	First Launch Pad
Launch Azimuth	:	140 deg

Vehicle Characteristics

Vehicle Height	:	44.4 m
Lift off mass	:	229 t
Propulsion Stages		
First Stage (PS1)	:	S139
Second Stage (PS2)	:	PL40
Third Stage (PS3)	:	HPS3
Fourth Stage (PS4)	:	L2.5

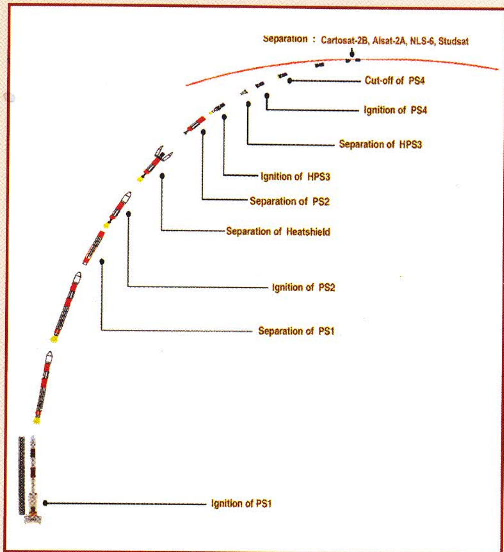




C15 - Vehicle Configuration

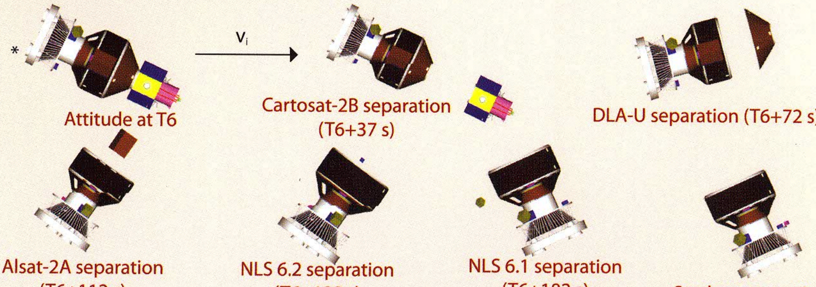
Payload Accommodation

PSLV-C15 Flight Sequence



Events	PSLV - C15 Mission		
	Time(s)	Altitude (km)	Inertial Velocity (m/s)
PS1 Ignition	0.0	0.026	451.9
PS1 Tail-off (RTD-T2)	109.40	45.96	1563.2
PS1 Separation	114.40	50.75	1542.1
PS2 Ignition	114.60	50.94	1541.1
Heat Shield Separation	183.70	115.13	2174.1
C L G Initiation	188.70	120.08	2243.5
PS2 cut-off (RTD-T3)	262.08	204.86	3661.3
PS2 Separation	265.08	208.94	3675.4
PS3 Ignition	266.28	210.56	3671.4
PS3 burn out (RTD-T4)	383.60	362.01	5671.9
PS3 Separation	517.60	512.80	5451.4
PS4 Ignition (RTD-T5)	528.52	521.77	5437.6
PS4 Cut-off (RTD T6)	1036.82	641.43	7531.2
Cartosat-2B Separation	1073.82	642.15	7537.4
DLA-U Separation	1108.82	642.85	7537.1
ALSAT-2A Separation	1148.82	643.69	7536.7
NLS-6.2 TISAT-1 Separation	1168.82	644.12	7536.5
NLS-6.1 AISSAT-1 Separation	1218.82	645.22	7535.9
STUDSAT Separation	1238.82	645.67	7535.7

Spacecraft Separation Sequence



Attitude at T6

Cartosat-2B separation (T6+37 s)

DLA-U separation (T6+72 s)

Alsat-2A separation (T6+112 s)

NLS 6.2 separation (T6+132 s)

NLS 6.1 separation (T6+182 s)

Studsat separation (T6+202 s)

* attitude shown are viewing from top

Payloads

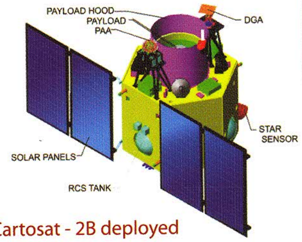
Cartosat-2B	693 kg
Alsat-2A	116 kg
NLS 6.1 (AISSat-1)	14 kg (6.5 kg for satellite)
NLS 6.2 (TISat-1)	3 kg (1 kg for satellite)
Studsat	3.6 kg (1.3 kg for satellite)

Cartosat-2B

Cartosat-2B is the third satellite in Cartosat-2 series.

Mission Objectives

- Obtaining high resolution (~ 1 m) scene specific spot imageries
- Generating cartographic products at cadastral level for urban and rural development



Cartosat - 2B deployed configuration

- Carries Panchromatic Camera with two mirror on axis system
- Relay optics operating in step & stare mode
- Three axes stabilized for sun pointing and imaging mode of operation
- Positioned at 630 km (mean) SSPO with 09.30 hrs ECT for 4 days revisit and one time special orbit at 560 km (recurrent , for daily revisit)
- ±26 deg steering across-track nominally for different modes of imaging

Alsat-2A

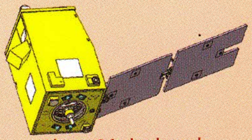
Alsat-2A is the first spacecraft in Alsat-2 series, an Algerian programme consisting of two similar satellites for earth observation in the low earth orbit

Mission Objectives

- Town and country planning
- Natural disaster forecast and monitoring
- Agricultural monitoring

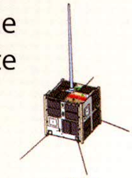
The spacecraft is built by EADS Astrium.
Alsat-2A is capable of imaging with a resolution of

- 2.5 m in panchromatic mode &
- 10 m in multi spectral mode (4 bands)


Alsat - 2A deployed configuration

NLS 6.1 (AISSat-1)

AISSat-1 is a technology demonstration spacecraft built for the Norwegian Defense Research Establishment by the Space Flight Laboratory at the University of Toronto Institute for Aerospace Studies (UTIAS), Canada.



AISSat-1
Deployed Configuration

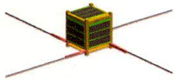
Mission objective

- To perform a survey of the VHF band centered on 162 MHz maritime AIS band

The payload is a maritime AIS (Automatic Identification System) receiver. The XPOD GNB Separation System of UTIAS is used to deploy the spacecraft in orbit.

NLS 6.2 (TISat-1)

The TISat-1 is a 1kg CubeSat of 100x100x100 mm and is built by University of Applied Sciences of Southern Switzerland (SUPSI).



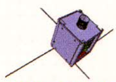
TISat-1
deployed configuration

Mission objectives

- To monitor the effect of atomic oxygen on various materials and detect man made 50Hz/60Hz light pollution on earth
- To test firmware for coding and modulation schemes for communication and validate redundant hardware architecture

Studsat

Studsat is developed by a consortium of Engineering Colleges of India.



Studsat deployed view

Mission objectives

- Imaging earth surface using CMOS camera with resolution of 95 m and transmitting data to earth station
- Developing ground support system

PRE LAUNCH OPERATIONS

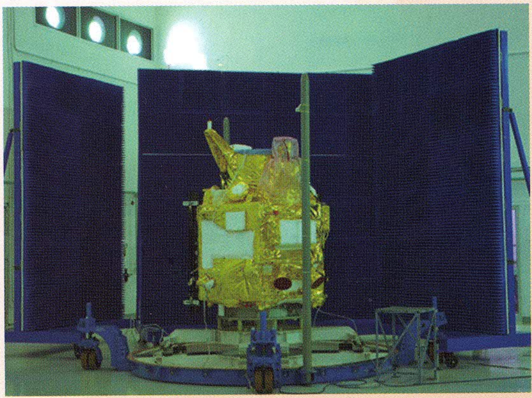
CBS assembly

PS1 stage at MST

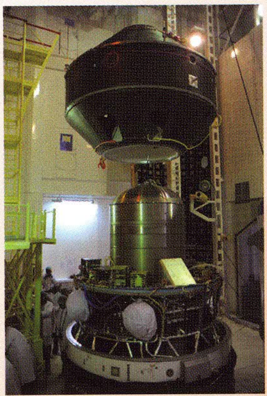
PS2 receipt at MST

PS3-PS4 moduling

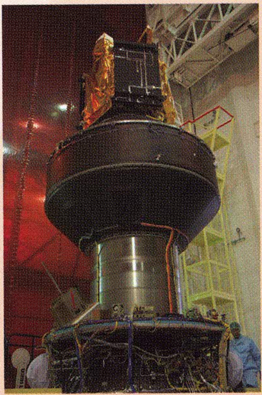
Vehicle ready to receive spacecrafts



Cartosat - 2B Testing



DLA + Alsat - 2A Module assembly to PS4



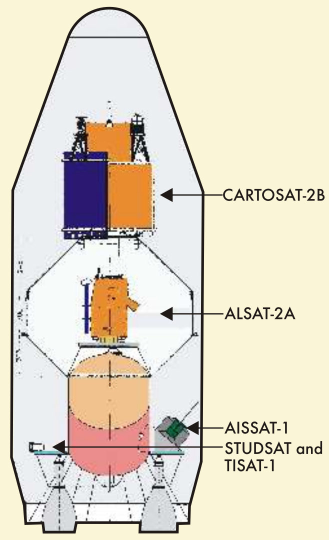
Satellites integrated to vehicle

HS closure

Published by : Documentation and Information Services-LV Projects, VSSC, Thiruvananthapuram
Printed at : St. Joseph's Press, Thiruvananthapuram

PSLV-C15

PSLV-C15 is the seventeenth flight of ISRO's versatile Polar Satellite Launch Vehicle, PSLV. In this flight, PSLV will place the 694 kg CARTOSAT-2B and four auxiliary payloads in a 630 km polar Sun Synchronous Orbit (SSO).



Payloads in PSLV-C15 envelope

PSLV was initially designed for launching 900 kg Indian Remote Sensing Satellites into a 900 km polar SSO. Since its first launch in 1993, the PSLV has been successively improved to attain its present capability of launching 1750 kg into a 630 km polar SSO. The major changes made in PSLV since its first launch include increase in the propellant loading of the first stage solid propellant motor as well as the strap-ons and in the second and fourth liquid propellant stages, improvement in the performance of the third stage motor by optimising motor case and enhanced propellant loading and employing a carbon composite payload adopter.

PSLV has also been made a more versatile vehicle for launching multiple satellites in polar SSOs as well as for launching satellites into Geosynchronous Transfer Orbit (GTO) and Low Earth Orbit (LEO). With fifteen consecutively successful launches, PSLV has emerged as a workhorse launch vehicle of ISRO and is offered for launching satellites of other space agencies also. Besides launching 17 Indian satellites, PSLV has launched 22 foreign satellites as well during 1994-2009 period into polar Sun Synchronous, Geosynchronous Transfer, Highly Elliptical and Low Earth Orbits and has repeatedly proved its reliability and versatility.

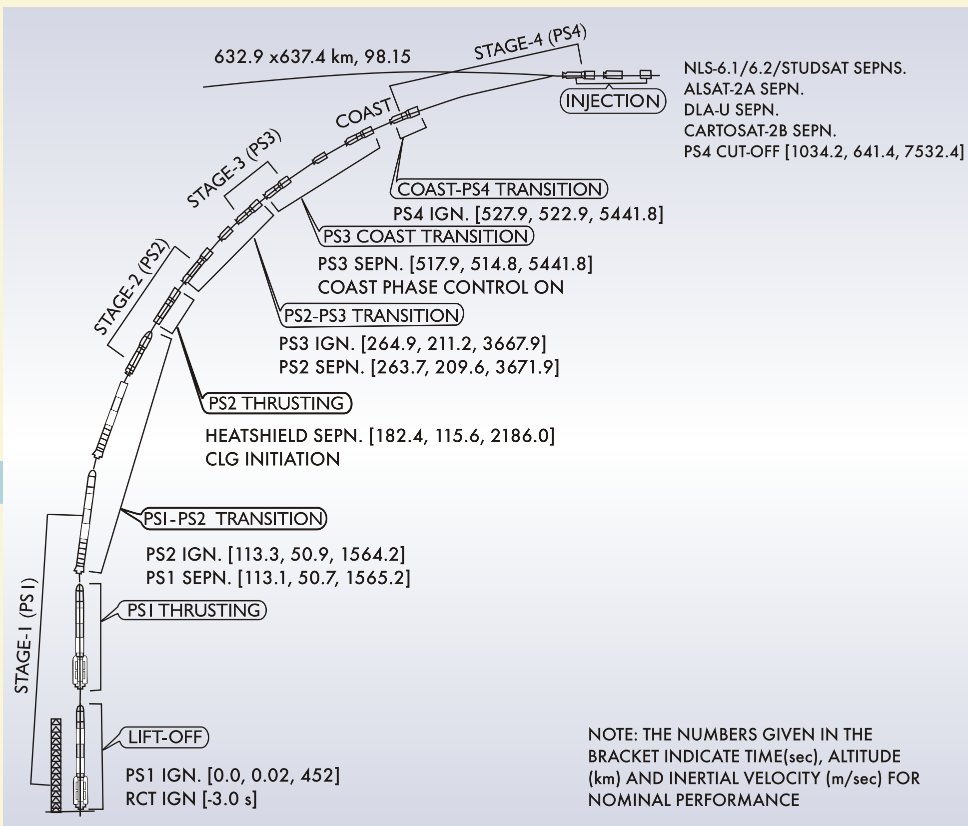
PSLV-C15 Stages at a Glance

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core (PS1)	PS2	PS3	PS4
Propellant	Solid HTPB Based	Liquid UH25 +N_2O_4	Solid HTPB Based	Liquid MMH+MON-3
Mass (Tonne)	138.0	41.0	7.6	2.5
Max Thrust (kN)	4817	799	238	7.3x2
Burn Time (Sec)	101	147	112	497
Stage Dia (m)	2.8	2.8	2.0	2.8
Stage Length (m)	20	12.8	3.6	2.6
Control	SITVC for Pitch & Yaw, Reaction Control Thrusters for Roll Control	Engine Gimbal for Pitch & Yaw, Hot Gas Reaction Control Motor for Roll Control	Flex Nozzle for Pitch & Yaw, PS 4 RCS for RollControl	Engine Gimbal for Pitch, Yaw & Roll, on-off RCS for Coast Phase Control

For PSLV-C15 mission, the 'core alone' version of PSLV has been chosen based on the weight of the payloads and the orbit to which they are to be placed. The 44 metre tall 'core alone' version of PSLV weighs 230 tons at lift-off. Six solid 'strap-on motors', clustered around the first stage of PSLV 'standard version' to enhance its thrust, are absent in 'core alone' version. PSLV-C15 is the sixth flight of the 'core alone' version of PSLV.

SALIENT FEATURES

Height : 44.4 metre
Weight : 230 Tonne
Payload Fairing:
3.2 metre diameter



PSLV-15 Mission Profile

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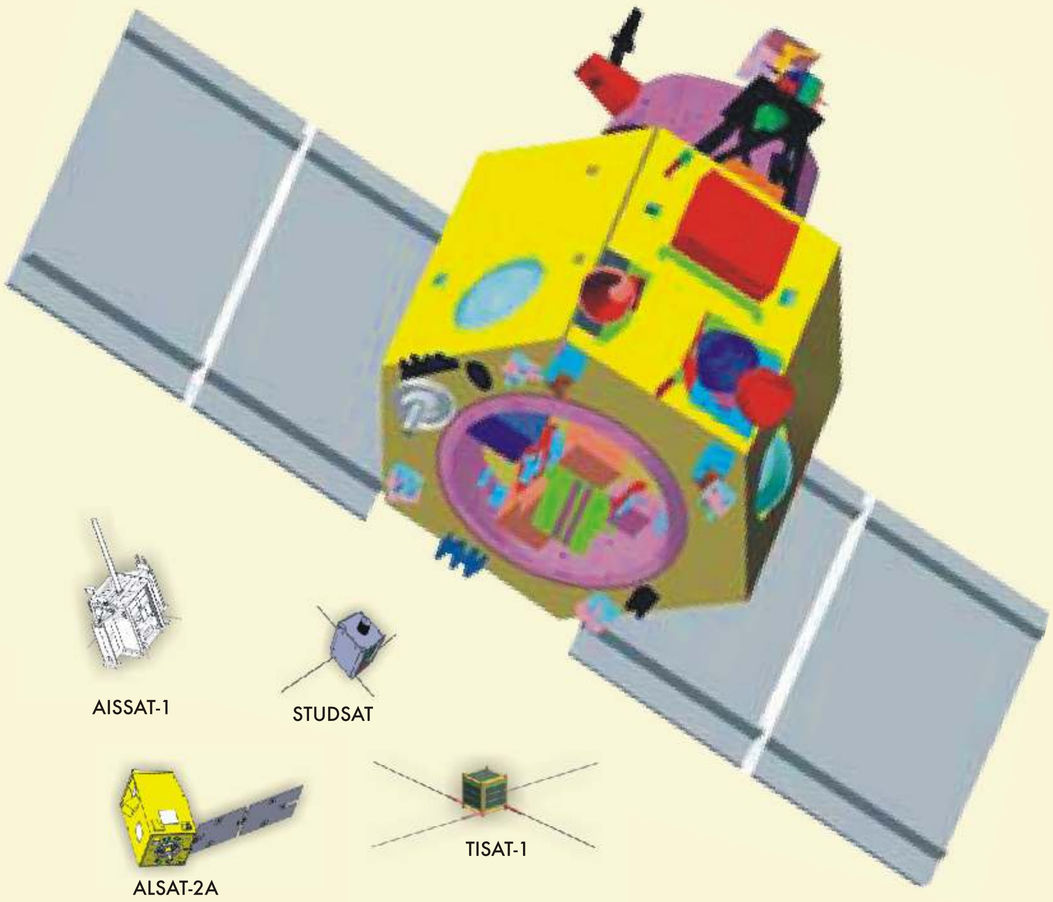
Publications and Public Relations, ISRO Headquarters, Antariksh Bhavan, New BEL Road, Bangalore-560 231, India
Printed at Mapco Offset Printers, Bangalore

www.isro.gov.in

June 2010

CARTOSAT-2B

CARTOSAT-2B is an advanced Remote Sensing Satellite built by ISRO. This is the latest in the Indian Remote Sensing Satellite Series and the seventeenth Remote Sensing Satellite of India. CARTOSAT-2B is mainly intended to augment remote sensing data services to the users of multiple spot scene imagery with 0.8 metre spatial resolution and 9.6 km swath in the panchromatic band. Cartosat-2 and 2A, two Indian Remote Sensing satellites in orbit, are currently providing such services. The 694 kg CARTOSAT-2B will be launched into a 630 km high polar Sun Synchronous Orbit (SSO) by the seventeenth flight of India's Polar Satellite Launch Vehicle (PSLV-C15).



CARTOSAT-2B carries a Panchromatic camera (PAN) similar to that of its two predecessors – CARTOSAT-2 and 2A. It is capable of imaging a swath (geographical strip of land) of 9.6 km with a resolution of 0.8 metre. The highly agile CARTOSAT-2B is steerable up to ± 26 deg along as well as across track to obtain stereoscopic imagery and achieve a four to five day revisit capability. The satellite also carries a Solid State Recorder with a capacity of 64 Giga Bits to store the images taken by its camera which can be read out later to the ground stations.

The multiple spot scene imagery sent by CARTOSAT-2B's PAN will be useful for village level/cadastral level resource assessment and mapping, detailed urban and infrastructure planning and development, transportation system planning, preparation of large-scale cartographic maps, preparation of micro watershed development plans and monitoring of developmental works at village/cadastral level.

Besides, CARTOSAT-2B's imagery can be used for the preparation of detailed forest type maps, tree volume estimation, village/cadastral level crop inventory, town/village settlement mapping and planning for comprehensive development, canal alignment, rural connectivity assessment, planning new rural roads and monitoring their construction, coastal landform/land use and coral/mangrove mapping and monitoring of mining activities.

SALIENT FEATURES

Orbit	:	Circular Polar Sun Synchronous
Orbit height	:	630 km
Orbit inclination	:	97.91 deg
Orbit period	:	97.44 min
Number of Orbits per day	:	14
Local Time of Equator crossing	:	9.30 AM
Revisit	:	4-5 days
Lift-off Mass	:	694 kg
Attitude and Orbit Control	:	3-axis body stabilised based on inputs from star sensors and gyros by using Reaction wheels, Magnetic Torquers and Hydrazine Thrusters
Power	:	Solar Array generating 930 W, Two 18 AH Ni-Cd batteries

PAYLOAD: PANCHROMATIC CAMERA (PAN)

Spatial Resolution	: 0.8 metre
Swath	: 9.6 km
Spectral Band	: 0.5-0.75 micrometre

CARTOSAT-2B Satellite In Clean Room
with its Panels Deployed

AUXILIARY PAYLOADS OF PSLV-C15

Besides its main payload – CARTOSAT-2B weighing 694 kg – PSLV-C15 will also carry four small satellites as auxiliary payloads. Of these, the 116 kg ALSAT-2A of Algeria is a small remote sensing satellite, whereas two Nanosats – NLS-6.1 AISSAT-1 weighing 6.5 kg built by Space Flight Laboratory of the University of Toronto, Canada and NLS-6.2 TISAT-1weighing one kg built by University of Applied Sciences of Switzerland – are for testing various satellite technologies. The fourth auxiliary payload – STUDSAT – is a Picosatellite weighing less than one kg built jointly by students from a consortium of seven engineering colleges from Karnataka and Andhra Pradesh.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PSLV-C16
RESOURCESAT-2 / YOUTHSAT / X-SAT

PSLV-

PSLV-C16 is the eighteenth flight of ISRO's Polar Satellite Launch Vehicle, PSLV. In this flight, the standard version of PSLV with six solid strap-on motors is used.

PSLV-C16 will place three satellites with a total payload mass of 1404 kg – RESOURCESAT-2 weighing 1206 kg, the Indo-Russian YOUTHSAT weighing 92 kg and Singapore's X-SAT weighing 106 kg – into an 822 km polar Sun Synchronous Orbit (SSO). PSLV-C16 will be launched from the First Launch Pad (FLP) at Satish Dhawan Space Centre SHAR, Sriharikota.

PSLV was initially designed for launching 900 kg Indian Remote Sensing Satellites into a 900 km polar SSO. Since the first launch in 1993, PSLV has been successively improved to attain its present capability.

The major changes made in PSLV since its first launch include changes in strap-on motors ignition sequence, increase in the propellant loading of the first stage and strap-on solid propellant motors as well as the second and fourth stage liquid propellant motors, improvement in the performance of the third stage motor by optimising motor case and enhanced propellant loading and employing a carbon composite payload adapter.

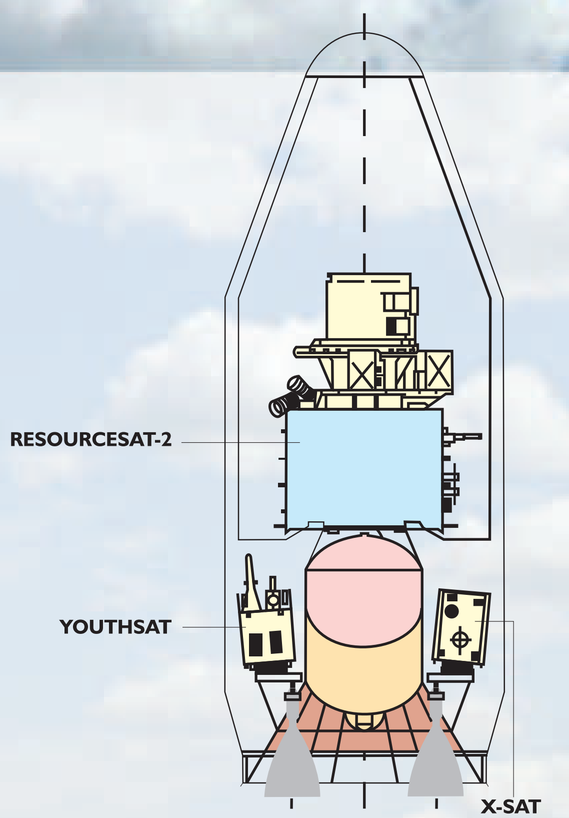
PSLV-C16 integration in progress inside the Mobile Service Tower of the First Launch Pad at Sriharikota

PSLV has also become a more versatile vehicle for launching multiple satellites in polar SSOs as well as Low Earth Orbits (LEO) and Geosynchronous Transfer Orbit (GTO). With sixteen successful launches, PSLV has emerged as the workhorse launch vehicle of ISRO and is offered for launching satellites for international customers also. During 1994-2010 period, PSLV has launched a total of 44 satellites, of which 25 satellites are from abroad and 19 are Indian satellites.

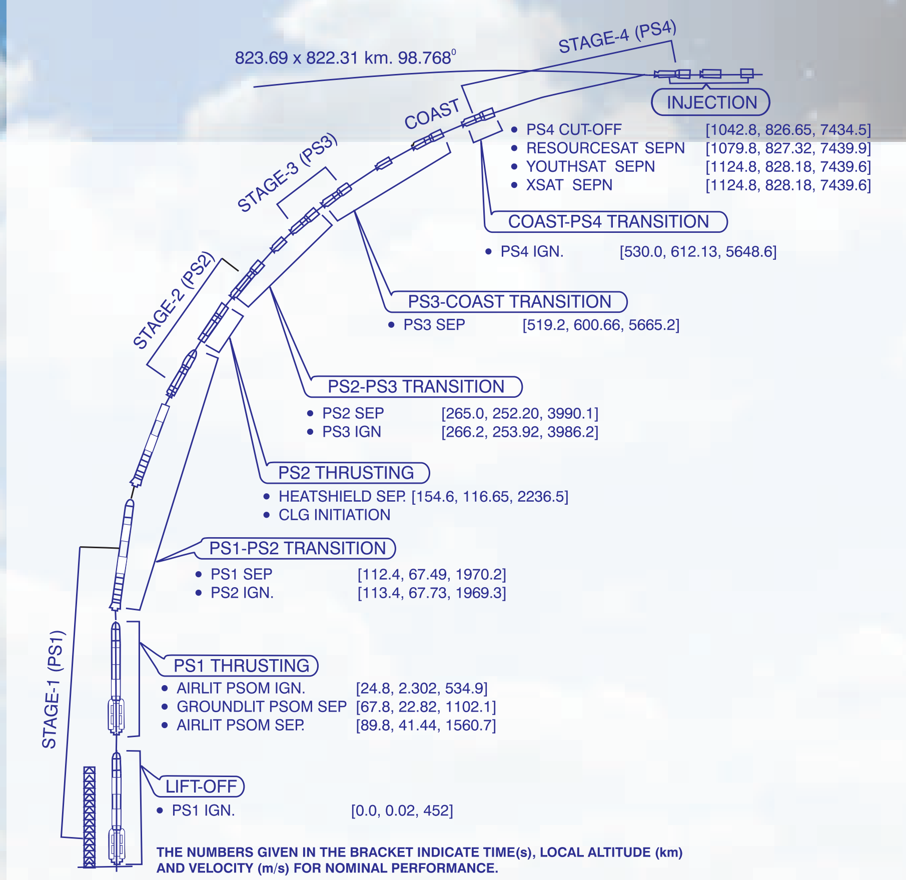
PSLV-C16 Details

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core Stage (PS1) + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB Based)	Liquid (UH25 + N_2O_4)	Solid (HTPB Based)	Liquid (MMH+MON-3)
Mass (Tonne)	138.0 (Core) + 6 x 9.0 (Strap-on)	41.0	7.6	2.5
Max Thrust (kN)	4703 (Core) + 6 x 635 (Strap-on)	804	244	7.3X2
Burn Time (Sec)	107 (Core) 50 (Strap-on)	151	116	510
Stage Dia (m)	2.8 (Core) 1.0 (Strap-on)	2.8	2.0	2.8
Stage Length (m)	20 (Core) 11.3 (Strap-on)	12.8	3.6	2.6

C16



Cross Sectional view of PSLV-C16 Payload Fairing



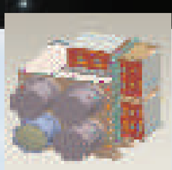
PSLV-C16 Flight Profile

RESOURCESAT-2 is the eighteenth Remote Sensing satellite built by ISRO. RESOURCESAT-2 is a follow on mission to RESOURCESAT-1, launched in 2003. RESOURCESAT-2 is intended to continue the remote sensing data services to global users provided by RESOURCESAT-1 that has far outlived its designed mission life. Also, it provides data with enhanced multispectral and spatial coverage as well.

RESOURCESAT-2 carries three cameras which are similar to those of RESOURCESAT-1. They are: a high resolution Linear Imaging Self Scanner (LISS-4) operating in three spectral bands in the Visible and Near Infrared Region (VNIR) with 5.8 m spatial resolution and steerable up to ± 26 deg across track to achieve a five day revisit capability; a medium resolution LISS-3 operating in three-spectral bands in VNIR and one in Short Wave Infrared (SWIR) band with 23.5 metre spatial resolution; and a coarse resolution Advanced Wide Field Sensor (AWiFS) operating in three spectral bands in VNIR and one band in SWIR with 56 metre spatial resolution.

LISS-4

RESOURCESAT-2



LISS-3

Important changes in RESOURCESAT-2 compared to RESOURCESAT-1 are: Enhancement of LISS-4 multispectral swath from 23 km to 70 km and improved Radiometric accuracy from 7 bits to 10 bits for LISS-3 and LISS-4 and 10 bits to 12 bits for AWIFS. Besides, suitable changes, including miniaturisation in payload electronics, have been made in RESOURCESAT-2.

AwiFS

AwiFS B

RESOURCESAT-2 also carries an additional payload known as AIS (Automatic Identification System) from COMDEV, Canada as an experimental payload for ship surveillance in VHF band to derive position, speed and other information about ships.

RESOURCESAT-2 carries two Solid State Recorders with a capacity of 200 Giga Bytes each to store the images taken by its cameras which can be read out later to ground stations.

Close up view of RESOURCESAT-2 during one of its prelaunch tests at ISRO Satellite Centre

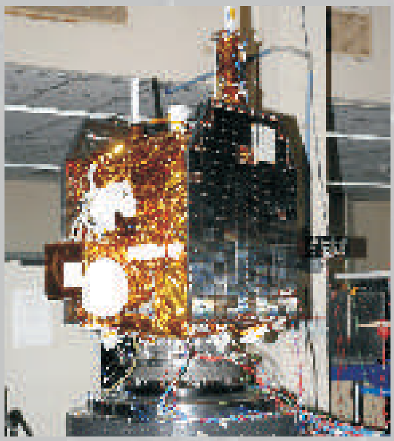
Salient Features

Orbit	:	Circular Polar Sun Synchronous
Orbit altitude at injection	:	822 ± 20 km (3 Sigma)
Orbit inclination	:	98.731 deg. ± 0.2 deg.
Orbit Period	:	101.35 min
Number of Orbits per day	:	14
Local Time of Equator crossing	:	10.30 AM
Repetivity	:	24 days
Lift-off Mass	:	1206 kg
Attitude and Orbit Control	:	3-axis body stabilised using Reaction Wheels, Magnetic Torquers and Hydrazine Thrusters
Power	:	Solar Array generating 1250 W at End of Life, two 24 AH Ni-Cd batteries
Mission Life	:	5 years

RESOURCESAT-2 in Clean Room at Sriharikota prior to its launch

Payload	LISS-4	LISS-3	AWiFS
Spatial Resolution (m)	5.8	23.5	56
Swath (km)	70.0 in MX mode and Mono mode	141	740
Spectral Band (microns)	0.52-0.59 0.62-0.68 0.77-0.86	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70	0.52-0.59 0.62-0.68 0.77-0.86 1.55-1.70
Quantisation (bits)	10	10	12
Data Rate (MBPS)	105	105	

YOUTHSAT, is a joint Indo-Russian satellite for stellar and atmospheric studies with the participation of students from Universities at graduate and post graduate level. With a lift-off mass of 92 kg, Youthsat intends to investigate the relationship between solar variability and thermosphere-Ionosphere changes. The satellite carries three payloads, of which two are Indian and one Russian. Together, they form a unique and comprehensive package of experiments for the investigation of the composition, energetics and dynamics of earth's upper atmosphere. The Indian payloads are:



Youthsat undergoing vibration test at ISRO Satellite Centre

1. **RaBIT (Radio Beacon for Ionospheric Tomography)**, which is a dual frequency beacon payload for mapping the Total Electron Content (TEC) of the Ionosphere.
2. **LiVHySI (Limb Viewing Hyper Spectral Imager)** is designed to perform airglow measurements of the Earth's upper atmosphere (100 to 1100 km)

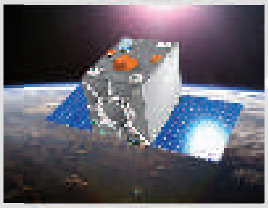
The Russian payload **SOLRAD** monitors the solar X- and γ ray fluxes and helps to study solar cosmic ray flux parameters and conditions of their penetration in the Earth's magnetosphere.

YOUTHSAT X-SAT

Salient Features

Orbit altitude at injection	:	Circular Polar Sun Synchronous 822 $\pm$ 20 km (3 Sigma)
Orbit inclination	:	98.731 deg. $\pm$ 0.2 deg.
Orbit Period	:	101.35 min
Number of Orbits per day	:	14
Lift-off Mass	:	92 kg
Dimension	:	1020 (Pitch) x 604 (Roll) x 1340 (Yaw) mm^3
Attitude and Orbit Control	:	3-axis body stabilised using Sun and Star Sensors, Miniature Magnetometer, Miniature Gyros, Micro Reaction Wheels and Magnetic Torquers
Power	:	Solar Array generating 230 W, one 10.5 AH Li-ion battery
Mechanisms	:	Paraffin Actuator based Solar Panel Hold Down and Release Mechanism
Mission Life	:	2 years

X-SAT, the third payload of PSLV-C16, is Singapore's first satellite. Weighing 106 kg at lift-off, X-SAT is a Mini Satellite with a multispectral camera IRIS as its primary payload. X-SAT mission mainly intends to demonstrate technologies related to satellite based remote sensing and onboard image processing.



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Published by Publications and Public Relations, ISRO HQ, Bangalore-560 231
Designed by Imagic Creatives, Bangalore. Printed at Glossy Prints, Bangalore.

April 2011

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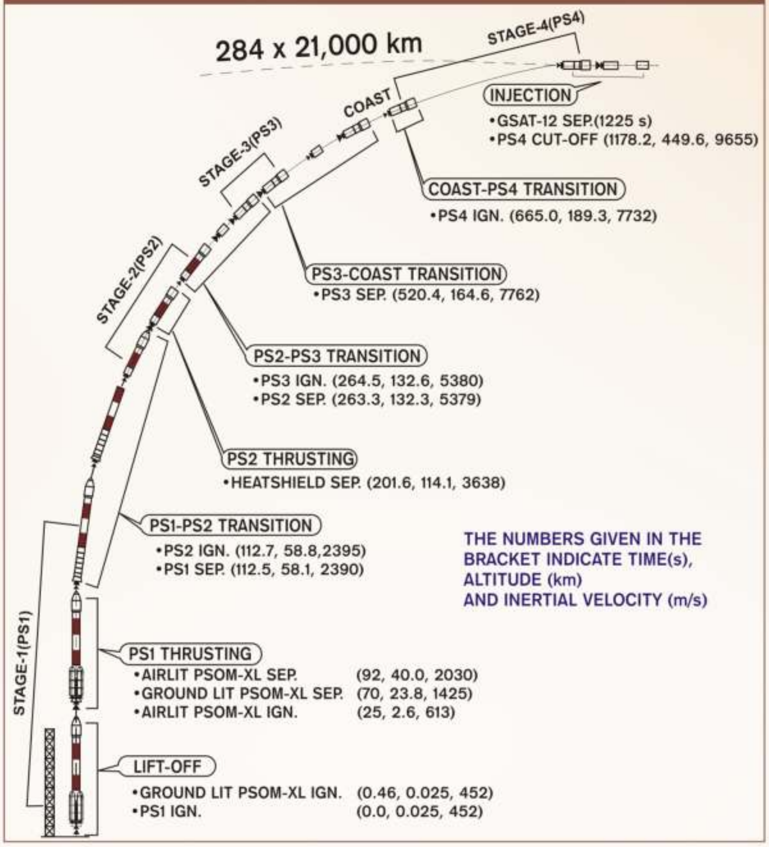
GSAT-12
PSLV-C17
PSLV C17
INDIA

Polar Satellite Launch Vehicle, in its nineteenth flight (PSLV-C17), will launch India's communication satellite GSAT-12 from the Second Launch Pad of Satish Dhawan Space Centre, (SDSC) SHAR. PSLV-C17 will use PSLV-XL version. In PSLV-XL, six extended solid strap-on motors are used wherein each strap-on will carry 12 tonnes of solid propellant. This is the second time such a configuration is being flown, earlier one being the PSLV-C11/Chandrayaan-1 mission.

PSLV at Second Launch Pad

PSLV-C17 Typical Flight Profile



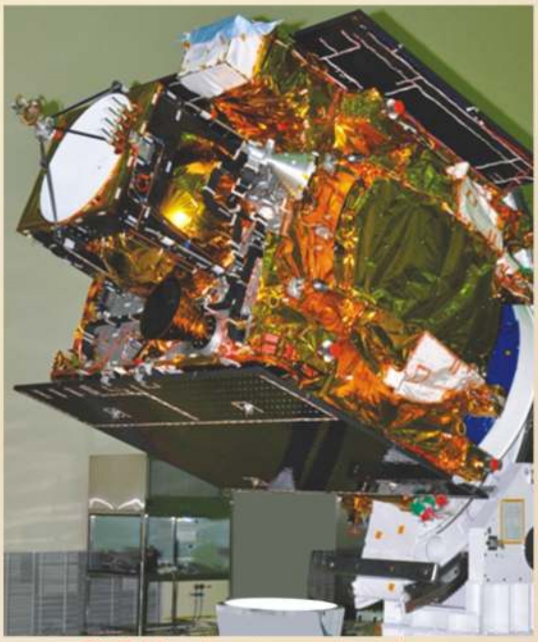
PSLV-C17

PSLV- C17 stages at a glance

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core Stage (PS1) + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB Based)	Liquid (UH25 + N_2O_4)	Solid (HTPB Based)	Liquid (MMH+MON-3)
Mass (tonne)	138.0 (Core) + 6 x 12.0 (Strap-on)	41.0	7.6	2.5
Max Thrust (kN)	4703 (Core) + 6 x 670 (Strap-on)	804	244	7.3X2
Burn Time (sec)	107 (Core) 55 (Strap-on)	151	116	510
Stage Dia (m)	2.8 (Core) 1.0 (Strap-on)	2.8	2.0	2.8
Stage Length (m)	20 (Core) 14.7 (Strap-on)	12.8	3.6	2.6

GSAT-12

GSAT-12, the latest communication satellite built by ISRO, weighs about 1410 kg at lift-off. GSAT-12 is configured to carry 12 Extended C-band transponders to meet the country's growing demand for transponders in a short turnaround time.



GSAT-12 undergoing pre-launch tests at ISRO Satellite Centre

Indian National Satellite (INSAT) system, established in 1983, is one of the largest domestic communication satellite systems in the Asia Pacific region. It presently comprises of eight satellites – INSAT-2E, INSAT-3A, INSAT-3C, INSAT-3E, INSAT-4A, INSAT-4B, INSAT-4CR and GSAT-8 providing 175 transponders in S, C, Ext-C and Ku-bands.

GSAT-12 is launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 21,000 km apogee (farthest point from the Earth) with an inclination of 17.9 deg with respect to the equatorial plane.

GSAT-12 undergoing pre-launch checks at SDSC SHAR

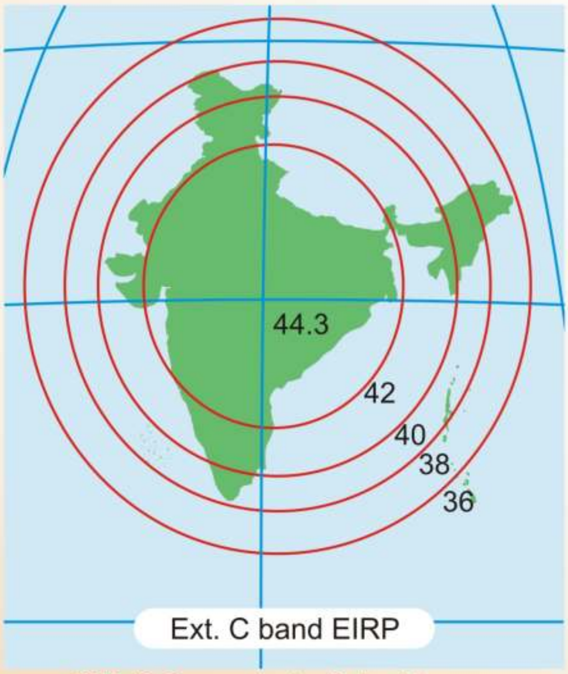
After injection into this preliminary orbit, solar panels of GSAT-12 satellite are automatically deployed and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres using the Liquid Apogee Motor (LAM) onboard the satellite, finally placing it in the circular Geostationary Orbit. After this, the deployment of the antenna and the three axis stabilisation of the satellite will be performed. GSAT-12 will be positioned at 83 deg. E longitude and co-located with INSAT-2E and INSAT-4A satellites.

The 12 Extended C-band transponders of GSAT-12 will augment the capacity in the INSAT system for various communication services like Tele-education, Telemedicine and for Village Resource Centres (VRC).

GSAT-12 Salient Features	
Orbit	Geostationary (83 deg. longitude) co-located with INSAT-2E and 4A
Lift-off Mass	1410 kg
Dry Mass	559 kg
Physical Dimensions	1.485 x 1.480 x 1.446 m cuboid
Propulsion (for orbit raising)	440 Newton Liquid Apogee Motor (LAM) with Mono Methyl Hydrazine (MMH) as fuel and Mixed Oxides of Nitrogen (MON-3) as oxidiser
Attitude & Orbit Control	3-axis body stabilised in orbit using Earth Sensors, Sun Sensors, Momentum and Reaction Wheels, Magnetic Torquers and eight 10 Newton and eight 22 Newton bipropellant thrusters
Power	Solar array providing 1430 Watts and one 64 Ah Li-Ion battery
Antennae	One 0.7 m diameter body mounted parabolic receive antenna and one 1.2 m diameter polarisation sensitive deployable antenna
Mission Life	About 8 years

COMMUNICATION PAYLOAD

GSAT-12 carries12 Extended C-band band transponders each with 36 MHz usable bandwidth with footprint covering Indian mainland with an Edge Of Coverage EIRP of 37 dBW and islands with an Edge Of Coverage EIRP of 33 dBW.



GSAT-12 Communication Payload Coverage

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Designed by Imagic Creatives Pvt. Ltd. Printed at Brilliant Printers Pvt. Ltd., Bangalore
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JULY 2011

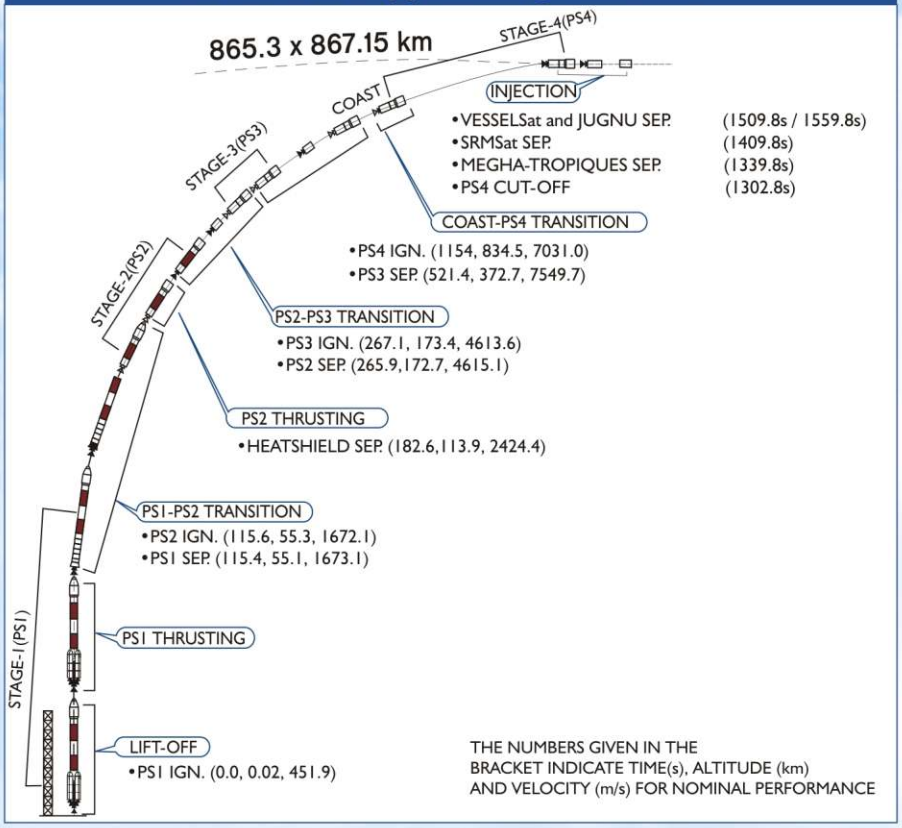

PSLV-C18
VesselSat-1
(Luxembourg)
SRMSat
(SRM University, Chennai)
Jugnu
(IIT, Kanpur)
Megha-Tropiques
(ISRO-CNES)
PSLV
C-18
INDIA
Megha-Tropiques / Jugnu / SRMSat / VesselSat-1

PSLV-C18

Polar Satellite Launch Vehicle, in its twentieth flight (PSLV-C18) will launch Megha-Tropiques satellite along with three auxiliary payloads with a total payload mass of 1047 kg from the first launch pad of Satish Dhawan Space Centre (SDSC SHAR). PSLV-C18 is the seventh flight of PSLV in 'core-alone' configuration i.e, without solid strap-on motors.

PSLV at First Launch Pad

PSLV-C18 Typical Flight Profile



PSLV-C18 Stages at a Glance

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	PS1	PS2	PS3	PS4
Propellant	Solid HTPB Based	Liquid UH25 and N_2O_4	Solid HTPB Based	Liquid MMH and MON-3
Propellant Mass (Tonne)	138.0	41.7	7.6	0.82
Max Thrust (kN)	4800	799	247	7.3x2
Burn Time (Sec)	100	148	108	163
Stage Dia (m)	2.8	2.8	2.0	2.8
Stage Length (m)	20	12.8	3.6	2.0
Control	•Secondary Injection Thrust Vector Control for Pitch & Yaw plane •Reaction Control Thrusters for Roll Control	• Engine Gimbal for Pitch & Yaw plane •Hot Gas Reaction Control System (RCS) for Roll Control	•Flex Nozzle for Pitch & Yaw plane •PS4 RCS for Roll Control	•Engine Gimbal for Pitch & Yaw plane •RCS for coast Phase Control

HTPB: Hydroxy Terminated Poly Butadiene
UH 25: Unsymmetrical di-methyl hydrazine & Hydrazine hydrate
MMH: Mono Methyl Hydrazine
MON: Mixed Oxides of Nitrogen

Megha-Tropiques

Megha-Tropiques Satellite under testing at SDSC SHAR

Megha-Tropiques is an Indo-French Joint Satellite Mission for studying the water cycle and energy exchanges in the tropics. The main objective of this mission is to understand the life cycle of convective systems that influence the tropical weather and climate and their role in associated energy and moisture budget of the atmosphere in tropical regions.

Megha-Tropiques will provide scientific data on the contribution of the water cycle to the tropical atmosphere, with information on condensed water in clouds, water vapour in the atmosphere, precipitation, and evaporation. With its circular orbit inclined 20 deg to the equator, the Megha-Tropiques is a unique satellite for climate research that should also aid scientists seeking to refine prediction models.

Megha-Tropiques Salient Features

Lift of Mass	1000 kg
Orbit	867 km with an inclination of 20 deg to the equator
Thermal	Passive system with IRS heritage
Power	1325 W (at End of Life)
	Two 24 AH NiCd batteries
TTC	S-band
AOCS	3-axis stabilised with 4 Reaction wheels, Gyros and Star sensors, Hydrazine based RCS
Solid State Recorder	16 Gb

Instruments

Megha-Tropiques carries the following four instruments:

- Scanning Microwave Imager for Detection of Rain and Atmospheric Structures (MADRAS) developed jointly by CNES and ISRO
- Sounder for Probing Vertical Profiles of Humidity (SAPHIR) from CNES
- Scanner for Radiation Budget (ScaRaB) from CNES
- Radio Occultation Sensor for Vertical Profiling of Temperature and Humidity (ROSA), procured from Italy

MADRAS

SAPHIR

ScaRaB

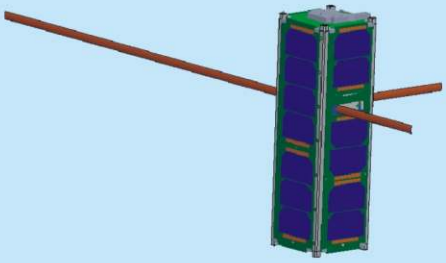
ROSA

Auxiliary Payloads of PSLV-C18

Besides Megha-Tropiques, PSLV-C18 carries three auxiliary payloads. Two of them – **Jugnu and SRMSat** – are from India, where as the third auxiliary payload – **VesselSat-1** – is from Luxembourg.

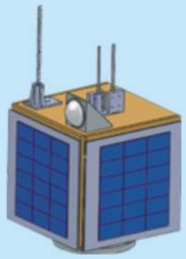
Jugnu

The nanosatellite Jugnu weighing 3 kg is designed and developed by Indian Institute of Technology, Kanpur under the guidance of ISRO. The satellite is intended to prove the indigenously developed camera system for imaging the Earth in the near infrared region and test image processing algorithms, to evaluate GPS receiver for its use in satellite navigation and to test indigenously developed MEMS based Inertial Measurement Unit (IMU) in space.



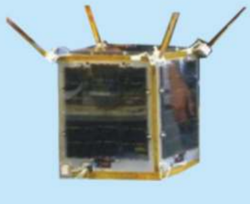
SRMSat

The nanosatellite SRMSat weighing 10.9 kg is developed by the students and faculty of SRM University attempts to address the problem of Global warming and pollution levels in the atmosphere by monitoring Carbon dioxide (CO_2) and water vapour (H_2O). The satellite uses a grating Spectrometer, which will observe absorption spectrum over a range of 900nm - 1700nm infrared range.



VesselSat-1

VesselSat-1 weighing 28.7 kg is a microsatellite developed and built by LuxSpace of Luxembourg. The satellite carries AIS (Automatic Identification System for ships) receivers to detect signals automatically transmitted by Vessels at sea in the region covered by the satellite footprint. The satellite carries two of such receivers, each with a dipole antenna composed of two 1.7m deployable elements.



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October 2011


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PSLV-C19

The Polar Satellite Launch Vehicle, in its 21st flight (PSLV-C19), will launch India's first Radar Imaging Satellite – RISAT-1 into a Polar Circular Orbit with an altitude of 480 km (± 40.5 km) and orbital inclination of 97.552^0 (± 0.2^0). RISAT-1 weighing 1858 kg is the heaviest satellite being launched by PSLV.

This is the third flight of the high end version (PSLV-XL) with six extended strap-on motors, each carrying 12 tonnes of solid propellant. (The two earlier flights of PSLV-XL were used to launch Chandrayaan-1 and GSAT-12 Communication Satellite)

PSLV-C19 Vehicle – Lift-off Mass: 321 tonne, Height: 44.5 m

PSLV-C19 on the First Launch Pad

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	Core Stage (PS1) + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB Based)	Liquid (UH25 + N_2O_4)	Solid (HTPB Based)	Liquid (MMH+MON-3)
Mass (tonne)	138.0 (Core), 6 x 12.0 (Strap-on)	41.7	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3X2
Burn Time (Sec)	101.5 (Core), 49.5 (Strap-on)	149	112.1	523
Stage Dia (m)	2.8 (Core), 1.0 (Strap-on)	2.8	2.0	2.8
Stage Length (m)	20 (Core), 14.7 (Strap-on)	12.8	3.6	2.6

HTPB: Hydroxy Terminated Poly Butadiene
UH 25: Unsymmetrical di-methyl Hydrazine + Hydrazine hydrate
MMH: Mono Methyl Hydrazine
MON: Mixed Oxides of Nitrogen

RISAT-1

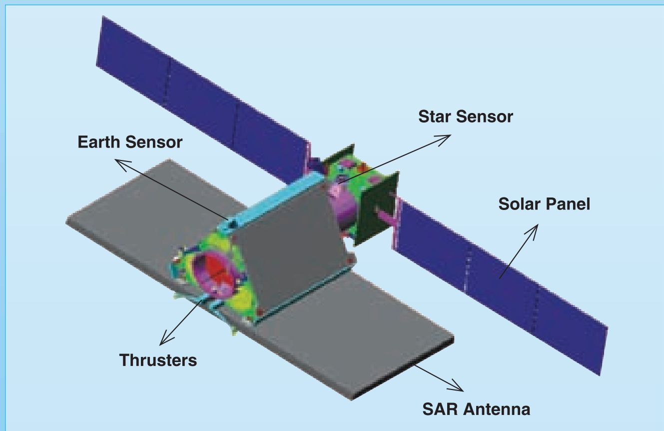
Radar Imaging Satellite-1 (RISAT-1) is a state of the art Microwave Remote Sensing Satellite carrying a Synthetic Aperture Radar (SAR) payload operating in C-band (5.35 GHz), which enables imaging of the earth surface features during both day and night under all weather conditions.

The satellite onboard propulsion system will be used to raise the orbital altitude to 536 km, with orbital inclination of 97.552^0 to place RISAT-1 into a Polar Sun-Synchronous Orbit.

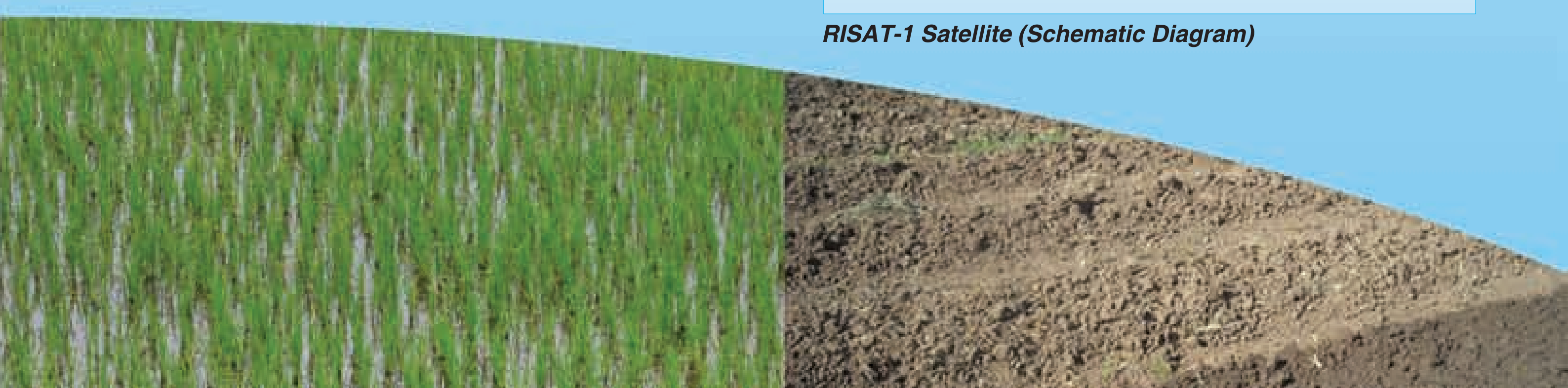
Salient Features

Orbit	:	Circular Polar Sun Synchronous
Orbit Altitude	:	536 km
Orbit Inclination	:	97.552^0
Orbit Period	:	95.49 min
Number of Orbits per day	:	14
Local Time of Equator Crossing	:	6:00 am/6:00 pm
Repetivity	:	25 days
Lift-off Mass	:	1858 kg
Attitude and Orbit Control	:	3-axis body stabilised using Reaction Wheels, Magnetic Torquers, and Hydrazine Thrusters
Power	:	Solar Array generating 2200 W and One 70 AH Ni-H2 battery
Nominal Mission Life	:	5 years

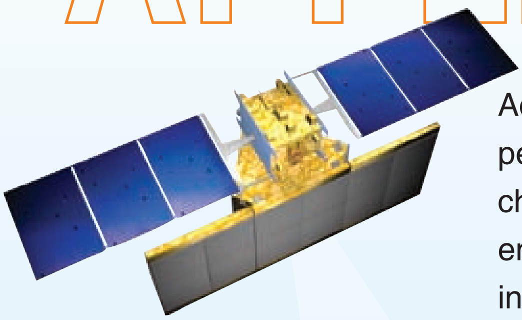
RISAT-1 Satellite undergoing tests



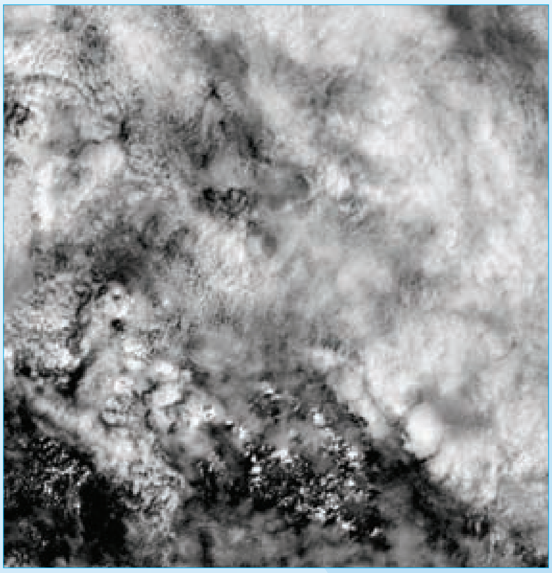
RISAT-1 Satellite (Schematic Diagram)



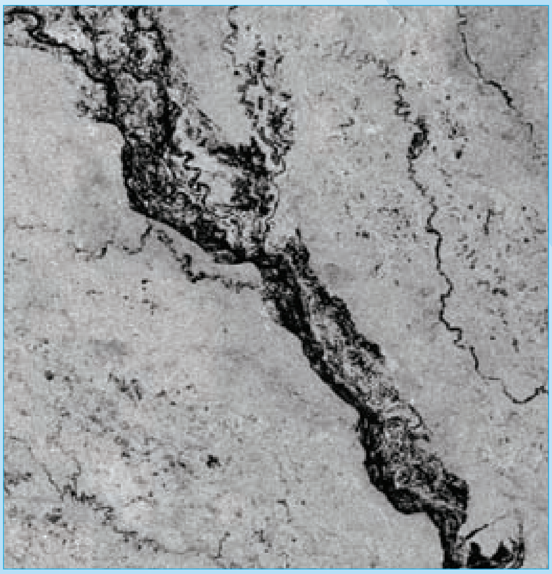
APPLICATIONS



Active Microwave Remote Sensing provides for cloud penetration and day-night imaging capability. These unique characteristics of C-band (5.35GHz) Synthetic Aperture Radar enables applications in agriculture, particularly paddy monitoring in kharif season and management of natural disasters like flood and cyclone.



A cloudy area as seen from
Optical Remote Sensing Sensor



A cloudy area as seen from
C-band Synthetic Aperture Radar

April 2012

INDIAN SPACE RESEARCH ORGANISATION

Published by Publications and Public Relations, ISRO HQ, Bangalore-560 231
Designed by Imagic Creatives, Bangalore. Printed at Aditya Printers, Bangalore.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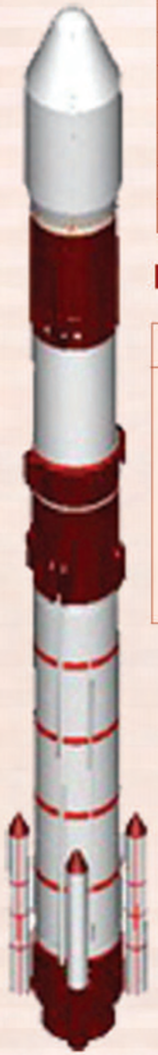
PSLV-C20/SARAL MISSION
PSLV
C20
INDIA
PSLV
PSLV PROJECT
Indian Space Research
Organisation

PSLV-C20/SARAL MISSION

PSLV-C20 is identified as a dawn-dusk SSPO mission carrying SARAL (Satellite with ARgos and ALtika), an ISRO-CNES (France) joint venture, as the primary satellite and six auxiliary satellites. PSLV Core Alone variant is employed for this mission. Dual Launch Adapter is used for accommodating the satellites. This is the 23rd PSLV mission of ISRO and 9th mission using PSLV Core Alone variant.



PSLV - C20 Vehicle Configuration

Satellites

SARAL	ISRO-CNES	409 kg
SAPPHIRE	MDA, Canada	148 kg
NEOSSat	MSCI, Canada	74 kg
NLS 8.1 (UniBRITE)	University of Vienna, Austria	14 kg
NLS 8.2 (BRITE)	Technical University, Graz, Austria	14 kg
NLS 8.3 (AAUSAT3)	Aalborg University, Denmark	3 kg
STRaND-1	SSTL, UK	6.5 kg

PSLV-C20 Vehicle Configuration : S139 + PL40 + HPS3 + L2.5

Vehicle Characteristics

Vehicle Height	:	44. 4 m
Lift of Mass	:	229.7 t
Propulsion Stages		
First Stage (PS1)	:	S139
Second Stage (PS2)	:	PL40
Third Stage (PS3)	:	HPS3
Fourth Stage (PS4)	:	L2.5

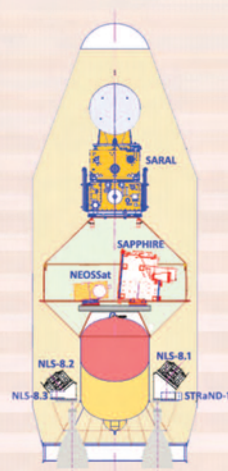
PSLV-C20 Stages at a Glance

	Stage 1 (PS1)	Stage 2 (PS2)	Stage 3 (HPS3)	Stage 4 (PS4)
Length (m)	20	12.8	3.6	2.0
Diameter (m)	2.8	2.8	2.0	2.8
Propellant	Solid (HTPB based)	Liquid (UH25+N_2O_4)	Solid (HTPB based)	Liquid (MON3+MMH)
Propellant mass (kg)	138190	41726	7650	2564

Mission Specifications

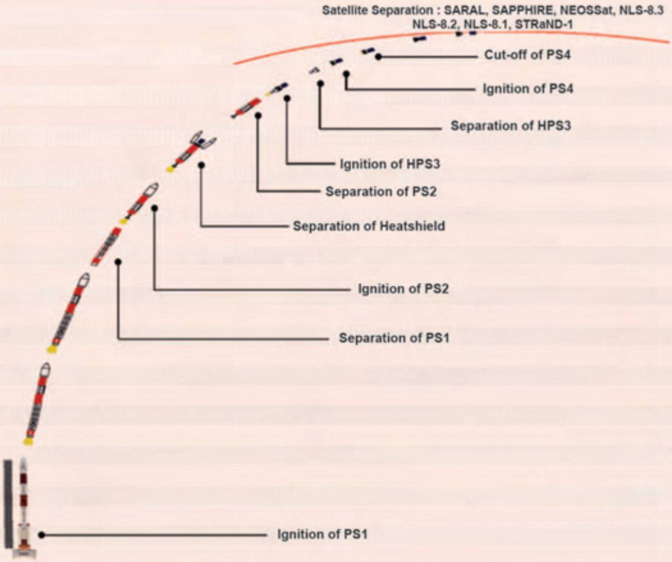
Semi Major Axis	:	7163.393 km
(*Altitude	:	785 km)
Inclination	:	98.536 deg
Launch time	:	17:56 Hrs
Launch Window	:	+20 min
LTDN	:	18:00 Hrs
Launch Pad	:	First Launch Pad

*w.r.t. mean Earth radius



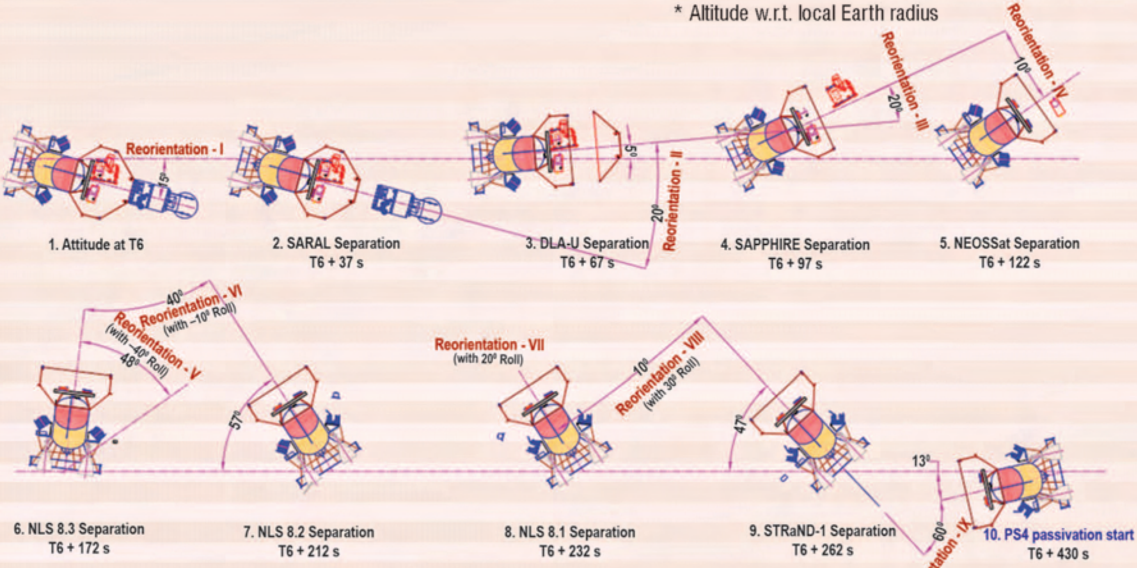
Payload Accommodation

PSLV - C20 / SARAL MISSION FLIGHT SEQUENCE



EVENTS	Time (s)	*Altitude (km)	Inertial Velocity (m/s)
RCT Ignition	-3.00	0.0262	451.89
PS1 Ignition	0.00	0.0262	451.89
PS1 Separation	113.14	52.112	1560.10
PS2 Ignition	113.34	52.306	1559.05
Heat Shield Separation	178.04	115.810	2096.37
PS2 Separation	265.04	222.051	3595.27
PS3 Ignition	266.24	223.778	3590.86
PS3 Separation	520.04	581.674	5302.02
PS4 Ignition	531.00	593.334	5283.92
PS4 Cutoff	1040.72	788.995	7453.38
SARAL Separation	1077.72	789.630	7459.46
DLA U Separation	1107.72	790.167	7459.28
SAPPHIRE Separation	1137.72	790.724	7459.10
NEOSSat Separation	1162.72	791.201	7458.93
NLS 8.3 (AAUSAT3) Separation	1212.72	792.187	7458.48
NLS 8.2 (BRITE) Separation	1252.72	793.000	7458.14
NLS 8.1 (UniBRITE) Separation	1272.72	793.413	7457.97
STRaND-1 Separation	1302.72	794.039	7457.69

* Altitude w.r.t. local Earth radius



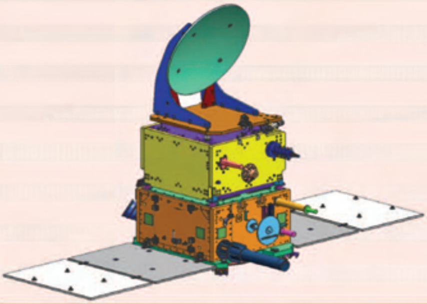
** Attitude shown are as viewed from top

Satellite Separation Sequence

SATELLITES IN PSLV-C20

SARAL

SARAL is the first mission under Indian Mini Satellite (IMS) Bus series-2, configured for 400 kg class satellite with miniaturization techniques proven in IMS-1. IMS-2 employs the modular concept for mounting the payload. It is an operational class Satellite Bus with complete redundancy in mainframe systems. The payload capability of this bus is around 200 kg. IMS-2 development is an important milestone as it is envisaged to be a workhorse for different types of operational missions in the coming years. This bus is aimed to carry medium size payloads useful for the applications in the areas of earth imaging, ocean & atmospheric studies, space science, etc., without significant changes in the bus.



SARAL deployed view

The SARAL mission results from the common interest of both ISRO and CNES in studying the ocean from space using altimetry system and in promoting maximum use of the ARgos Data Collecting System.

Payloads

- Payload Interface Module (PIM) containing ALtika & ARgos
- Solid state C Band Transponder (SCBT) from VSSC, ISRO

The PIM is provided by CNES, France.

The scientific objectives of PIM :

- Marine meteorology and sea state forecasting
- Operational oceanography
- Seasonal forecasting
- Climate and Mean sea level monitoring
- Ocean, Earth system and climate research
- Study on Animal migration

Data products from ALtika payload shall be provided to oceanographic research community to study the following:

- Ocean meso-scale variability studies with improved vertical and spatial resolution
- Data assimilation in a global ocean model
- Coastal altimetry
- Continental waters
- Inland ice sheet monitoring
- Light rainfall and clouds climatology
- Geodetic reference system determination

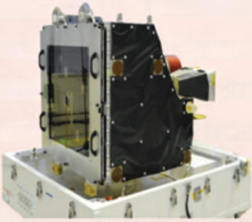
The main objective of ARgos Payload is to collect data from Data Collection Platform (DCP) and provide to the user.

Applications of the ARgos payload:

- Locating buoys and fishing vessels
- Collecting environmental data like ocean temperature profiles, currents and salinity
- Tracking animals, birds, seals etc

SAPPHIRE

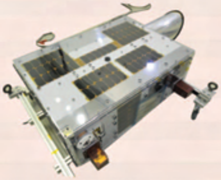
The satellite is built by MacDonald, Dettwiler and Associates (MDA), Canada. The primary objective of the SAPPHIRE mission is to deploy an operationally acceptable space based surveillance to contribute to the US Space Surveillance Network (SSN). SAPPHIRE is a space based optical sensor system to perform surveillance of orbit in deep space and to deliver Resident Space Objects (RSOs) tracking information in the orbit range of 6000 to 40000 km. ISRO's Ball Lock separation system IBL-298 is being used for separating the satellite.



SAPPHIRE

NEOSSat

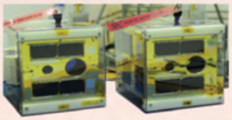
The NEOSSat (Near-Earth Object Surveillance Satellite) is built by Microsat Systems Canada Inc. (MSCI). The satellite has a space telescope dedicated for detecting and tracking asteroids and satellites in Geo-stationary orbit. NEOSSat also uses IBL-298 separation system.



NEOSSat

NLS 8.1 (UniBRITE) and NLS 8.2 (BRITE)

UniBRITE and BRITE are the two scientific satellites launched and operated by Austria. UniBRITE is built for the University of Vienna and BRITE for Technical University, Graz by the Space Flight Laboratory, University of Toronto Institute for Aerospace Studies (UTIAS), Austria. The objective of UniBRITE mission is to photometrically measure low-level oscillations and temperature variations in stars brighter than visual magnitude (4.0), with unprecedented precision and temporal coverage not achievable through terrestrial based methods.



NLS 8.1 and 8.2

BRITE is similar to the UniBRITE spacecraft, with the exception of the optical filter within the payload, which is used to observe the blue region of the light spectrum.

Both the satellites use XPOD GNB separation system provided by the UTIAS, Canada

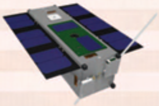
NLS 8.3 (AAUSAT3)

AAUSAT3 is the third student cubesat from Aalborg University in Denmark. The payloads are a dual band AIS receiver for feasibility study of receiving AIS signals from ships in arctic regions and a Phoenix GPS receiver from DLR, Germany. XPOD single separation system is being used for separation of the satellite.

NLS 8.3

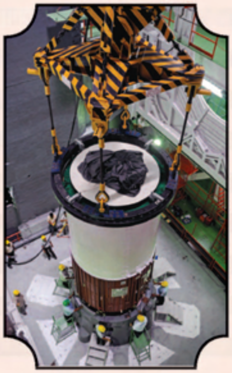
STRaND-1

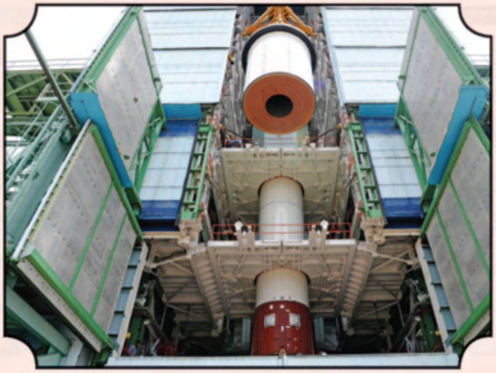
STRaND-1 is the first satellite in the series of Surrey Training, Research and Nanosatellite Development programme, built by SSTL (Surrey Satellite Technology Ltd), UK. The mission objective is to fly state-of-the art technologies and new developments in low Earth orbit.



STRaND-1

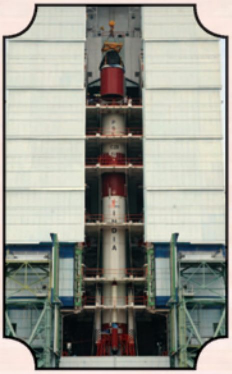
Payloads are Smart Phone, Resistojet Propulsion System and Pulsed Plasma Electrical Propulsion System. ISIPOD separation system 3U class is being used for separation of the satellite.

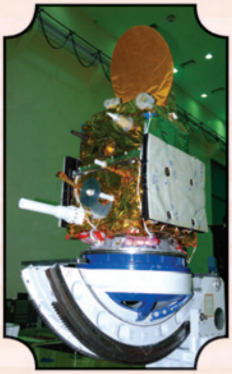

CBS+NES Stacking

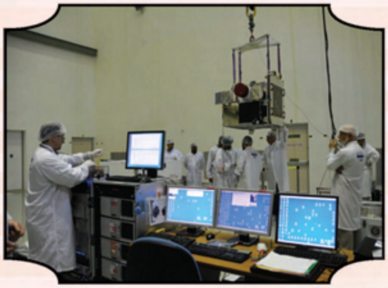

PS1 Segment Stacking

PS2 Stage Checks at SPB

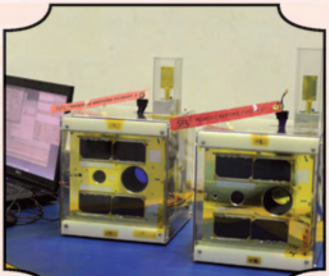
PRE LAUNCH OPERATIONS


PS3-PS4 Module Stacking


SARAL Testing


SAPPHIRE Testing


NEOSSat Testing


NLS 8.1/8.2 Testing

Published by : Documentation and Information Services-LV Projects, VSSC, Thiruvananthapuram
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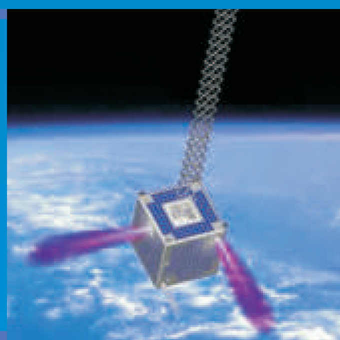
PSLV-C21

100th Indian Space Mission

SPOT 6
(France)

PROITERES
(Japan)



PSLV-C21 at the First Launch Pad

India's Polar Satellite Launch Vehicle, in its twenty second flight (PSLV-C21), will launch the French earth observation satellite SPOT 6 along with a micro-satellite from Japan into a 655 km polar orbit inclined at an angle of 98.23 deg to the equator. PSLV-C21 will be launched from the First Launch Pad of Satish Dhawan Space Centre (SDSC SHAR), Sriharikota.

With a lift-off mass of 712 kg, SPOT 6 is the heaviest satellite to be launched by PSLV for an international customer. The Japanese micro-satellite PROITERES, carried as an auxiliary payload, has a lift-off mass of 15 kg. PSLV-C21 is the eighth flight of PSLV in 'core-alone' configuration (without solid strap-on motors).

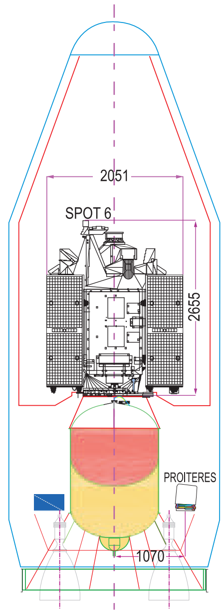
Nozzle End Segment of PSLV-C21 first stage being placed on launch pedestal

Hoisting of PSLV-C21 second stage

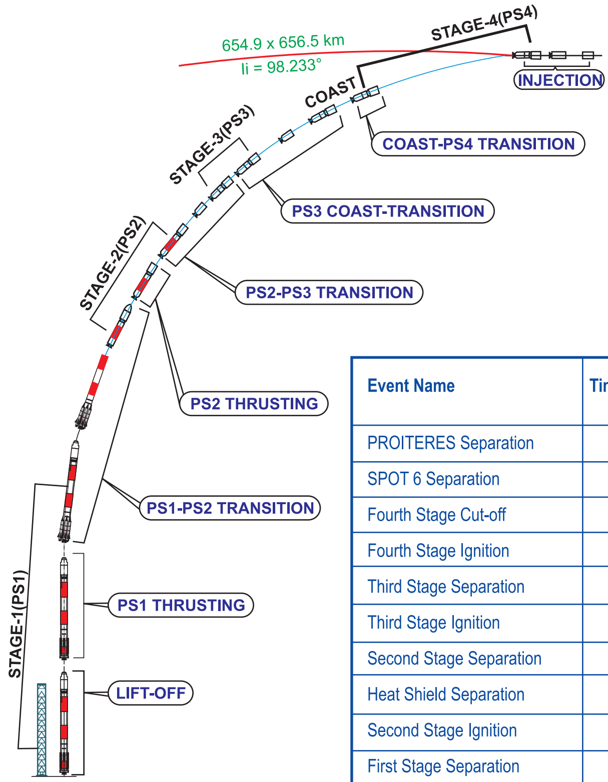
PSLV-C21 Stages at a Glance

	STAGE-1	STAGE-2	STAGE-3	STAGE-4
Nomenclature	PS1	PS2	PS3	PS4
Propellant	Solid (HTPB Based)	Liquid (UH25 +N_2O_4)	Solid (HTPB Based)	Liquid (MMH+MON-3)
Mass (Tonne)	138.0	41.0	7.6	2.5
Max Thrust (kN)	4787	804	242	7.3x2
Burn Time (Sec)	102	148	110	526
Stage Dia (m)	2.8	2.8	2.0	2.8
Stage Length (m)	20	12.8	3.6	2.6
Control	SITVC for Pitch & Yaw, Reaction Control Thrusters for Roll Control	Engine Gimbal for Pitch & Yaw, Hot Gas Reaction Control Motor for Roll Control	Flex Nozzle for Pitch & Yaw, PS4 Reaction Control System (RCS) for Roll Control	Engine Gimbal for Pitch, Yaw & Roll, on-off RCS for Coast Phase Control

HTPB: Hydroxyl Terminated Poly Butadiene, UH25: Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate, MMH: Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen, SITVC: Secondary Injection Thrust Vector Control



SPOT 6 and PROITERES in PSLV-C21 Envelope



Event Name	Time after lift-off (second)	Altitude (kilometre)	Velocity (metres per second)
PROITERES Separation	1128.8	660.2	7527.4
SPOT 6 Separation	1078.8	659.3	7527.8
Fourth Stage Cut-off	1041.8	658.6	7520.8
Fourth Stage Ignition	533.5	575.2	5206.7
Third Stage Separation	521.9	565.1	5222.7
Third Stage Ignition	268.3	244.1	3444.0
Second Stage Separation	267.1	242.3	3448.8
Heat Shield Separation	195.7	149.8	2138.1
Second Stage Ignition	115.7	58.1	1439.5
First Stage Separation	115.5	57.9	1440.7
First Stage Ignition	0.0	0.02	452

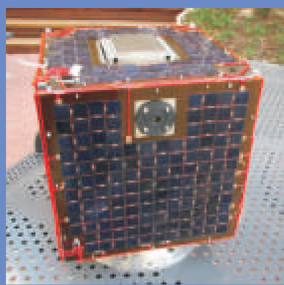
PSLV-C21 Typical Flight Profile

Payloads of PSLV-C21

SPOT 6 is a French Earth Observation Satellite capable of imaging the earth with a resolution of 1.5 metres. This latest generation optical remote sensing satellite is built by Astrium SAS, a leading European space technology company.

Besides SPOT 6, PSLV-C21 carries PROITERES, a 15 kg Japanese micro-satellite as an auxiliary payload. PROITERES is intended to study powered flight of a small satellite by an electric thruster and observe Kansai district in Japan with a high-resolution camera.

SPOT 6 in clean room (712 kg)



PROITERES (15 kg)

SATELLITES OF OTHER COUNTRIES LAUNCHED BY PSLV

SL. NO.	NAME	COUNTRY	DATE OF LAUNCH	MASS (KG)	LAUNCH VEHICLE
1.	DLR-TUBSAT	GERMANY	26.05.1999	45	PSLV-C2
2.	KITSAT-3	REPUBLIC OF KOREA	26.05.1999	110	PSLV-C2
3.	BIRD	GERMANY	22.10.2001	92	PSLV-C3
4.	PROBA	BELGIUM	22.10.2001	94	PSLV-C3
5.	LAPAN-TUBSAT	INDONESIA	10.01.2007	56	PSLV-C7
6.	PEHUENSAT-1	ARGENTINA	10.01.2007	6	PSLV-C7
7.	AGILE	ITALY	23.04.2007	350	PSLV-C8
8.	TECSAR	ISRAEL	21.01.2008	300	PSLV-C10
9.	CAN-X2	CANADA	28.04.2008	7	PSLV-C9
10.	CUTE-1.7	JAPAN	28.04.2008	5	PSLV-C9
11.	DELFI-C3	THE NETHERLANDS	28.04.2008	6.5	PSLV-C9
12.	AAUSAT-II	DENMARK	28.04.2008	3	PSLV-C9
13.	COMPASS-I	GERMANY	28.04.2008	3	PSLV-C9
14.	SEEDS	JAPAN	28.04.2008	3	PSLV-C9
15.	NLS-5	CANADA	28.04.2008	16	PSLV-C9
16.	RUBIN-8	GERMANY	28.04.2008	8	PSLV-C9
17.	CUBESAT-1	GERMANY	23.09.2009	1	PSLV-C14
18.	CUBESAT-2	GERMANY	23.09.2009	1	PSLV-C14
19.	CUBESAT-3	TURKEY	23.09.2009	1	PSLV-C14
20.	CUBESAT-4	SWITZERLAND	23.09.2009	1	PSLV-C14
21.	RUBIN-9.1	GERMANY	23.09.2009	1	PSLV-C14
22.	RUBIN-9.2	GERMANY	23.09.2009	1	PSLV-C14
23.	ALSAT-2A	ALGERIA	12.07.2010	116	PSLV-C15
24.	NLS-6.1 AISSAT-1	CANADA	12.07.2010	6.5	PSLV-C15
25.	NLS-6.2 TISAT-1	SWITZERLAND	12.07.2010	1	PSLV-C15
26.	X-SAT	SINGAPORE	20.04.2011	106	PSLV-C16
27.	VesselSat-1	LUXEMBOURG	12.10.2011	28.7	PSLV-C18

Sept 2012

Indian Space Research Organisation
Publications and Public Relations, ISRO Headquarters, Antariksh Bhavan
New BEL Road, Bangalore - 560 0231, India www.isro.gov.in

Design: smartworks.in, Bangalore | Printed at: Brilliant Printers Pvt. Ltd., Bangalore - 560 094

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PSLV-C22/IRNSS-1A

FULLY INTEGRATED PSLV-C22 WITH IRNSS-1A ON LAUNCHPAD

PSLV-C22

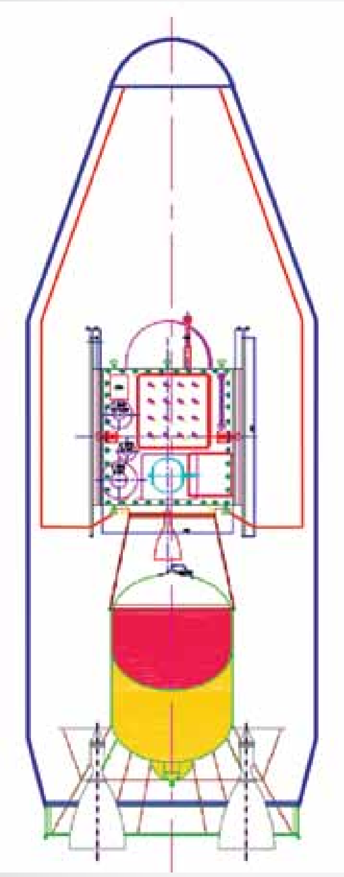
Polar Satellite Launch Vehicle, in its twenty fourth flight (PSLV-C22), will launch India's first dedicated navigational satellite IRNSS-1A. The launch will take place from the First Launch Pad (FLP) of Satish Dhawan Space Centre, (SDSC) SHAR, Sriharikota. PSLV-C22 will use 'XL' version of PSLV. This is the fourth time such a configuration is being flown, earlier three being PSLV-C11/ Chandrayaan-1, PSLV-C17 / GSAT-12 and PSLV-C 19 / RISAT-1 missions.

PSLV-C22 AT A GLANCE

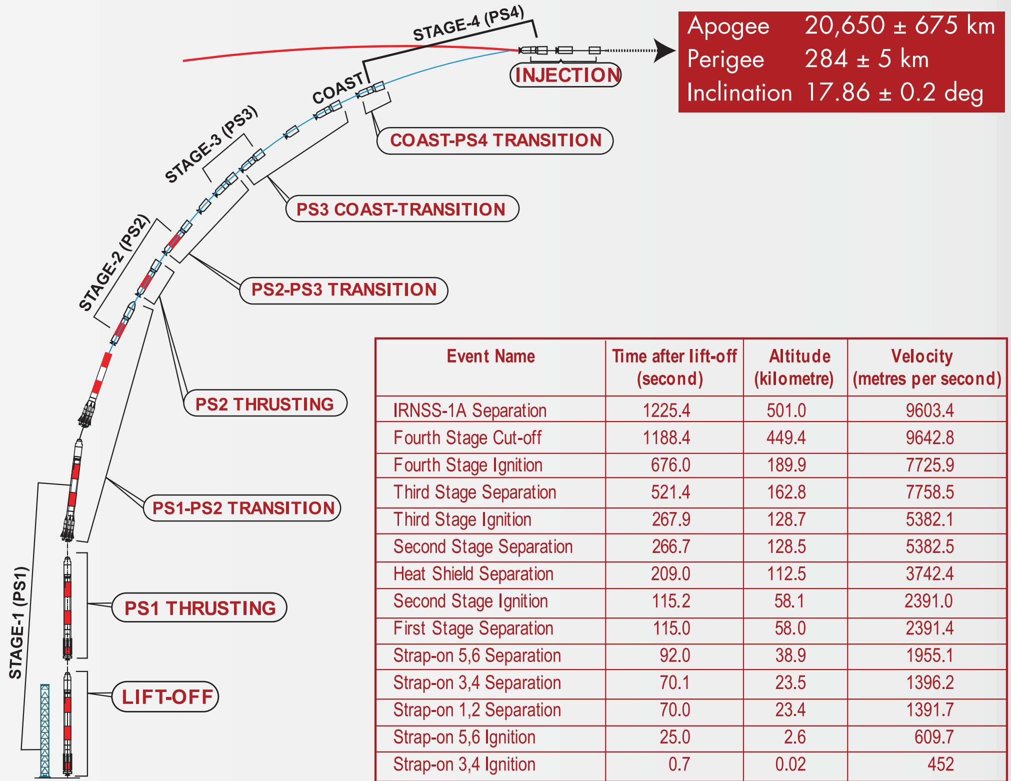
Lift-off Mass: 320 tons   Height: 44 metres

	Stage-1	***Stage-2***	***Stage-3***	***Stage-4***
Nomenclature	Core Stage PS1+ 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Mass (T)	138 (Core), 6 x 12 (Strap-on)	41.7	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
Burn Time (s)	101.5 (Core), 49.5 (Strap-on)	149	112.1	513
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	2.8
Stage Length (m)	20 (Core), 14.7 (Strap-on)	12.5	3.6	2.6

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen



IRNSS-1A in PSLV-C22 Envelope



Event Name	Time after lift-off (second)	Altitude (kilometre)	Velocity (metres per second)
IRNSS-1A Separation	1225.4	501.0	9603.4
Fourth Stage Cut-off	1188.4	449.4	9642.8
Fourth Stage Ignition	676.0	189.9	7725.9
Third Stage Separation	521.4	162.8	7758.5
Third Stage Ignition	267.9	128.7	5382.1
Second Stage Separation	266.7	128.5	5382.5
Heat Shield Separation	209.0	112.5	3742.4
Second Stage Ignition	115.2	58.1	2391.0
First Stage Separation	115.0	58.0	2391.4
Strap-on 5,6 Separation	92.0	38.9	1955.1
Strap-on 3,4 Separation	70.1	23.5	1396.2
Strap-on 1,2 Separation	70.0	23.4	1391.7
Strap-on 5,6 Ignition	25.0	2.6	609.7
Strap-on 3,4 Ignition	0.7	0.02	452
Strap-on 1,2 Ignition	0.5	0.02	452
First Stage Ignition	0.0	0.02	452

PSLV-C22 TYPICAL FLIGHT PROFILE

Nozzle End Segment of PSLV-C22 first stage being positioned over the Launch Pedestal

PSLV-C22 first stage with strap-ons inside mobile service tower

PSLV-C22 Second Stage liquid engine being lowered into the interstage

The Satellite

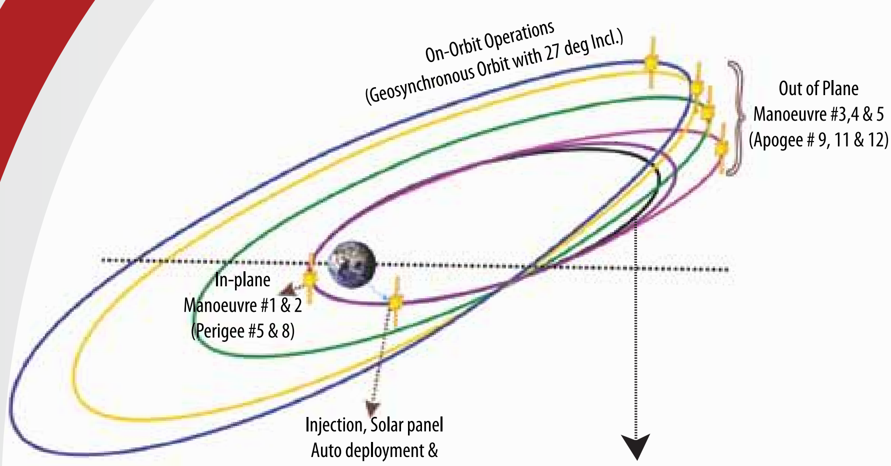
IRNSS-1A undergoing tests in clean room

IRNSS-1A is the first satellite in the Indian Regional Navigation Satellite System (IRNSS). It is one of the seven satellites constituting the IRNSS space segment. The satellite has a lift-off mass of 1425 kg. The two solar panels with Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1A maintains the satellite's orientation, with the help of reaction wheels, magnetic torquers and thrusters. The propulsion system of IRNSS-1A consists of a Liquid Apogee Motor (LAM) and thrusters.

IRNSS-1A is launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 20,650 km apogee (farthest point from the Earth) with an inclination of 17.86 deg with respect to the equatorial plane.

After injection into this preliminary orbit, solar panels of IRNSS-1A are automatically deployed and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres using the Liquid Apogee Motor (LAM) onboard the satellite, finally placing it in the circular geosynchronous orbit at 55 deg East location with an inclination of 29 deg with respect to the equator.

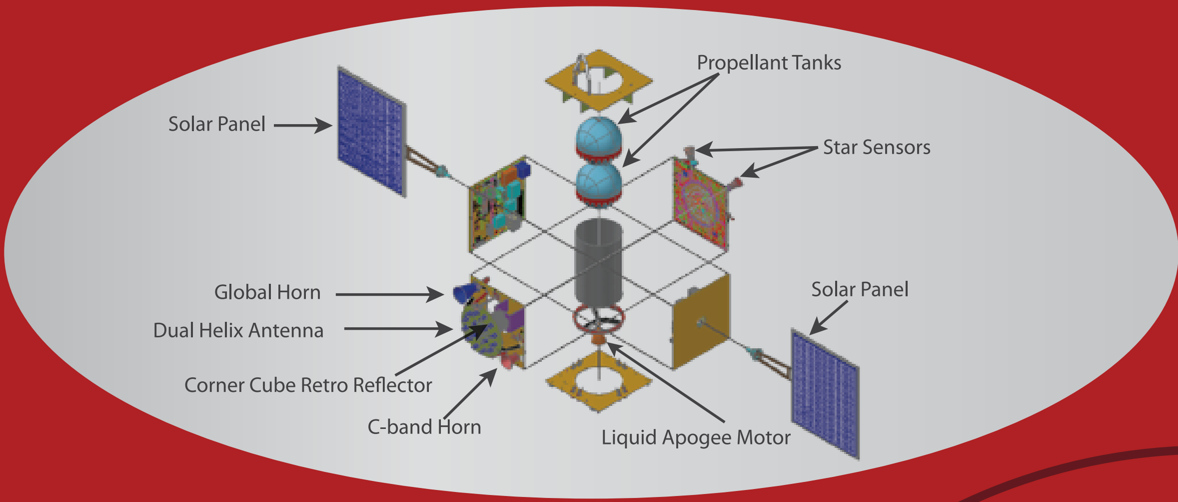
IRNSS-1A: Sequence of Events
(Nominal Orbit Raising Strategy)



Apogee	20,650 ± 675 km
Perigee	284 ± 5 km
Inclination	17.86 ± 0.2 deg

IRNSS-1A salient features:

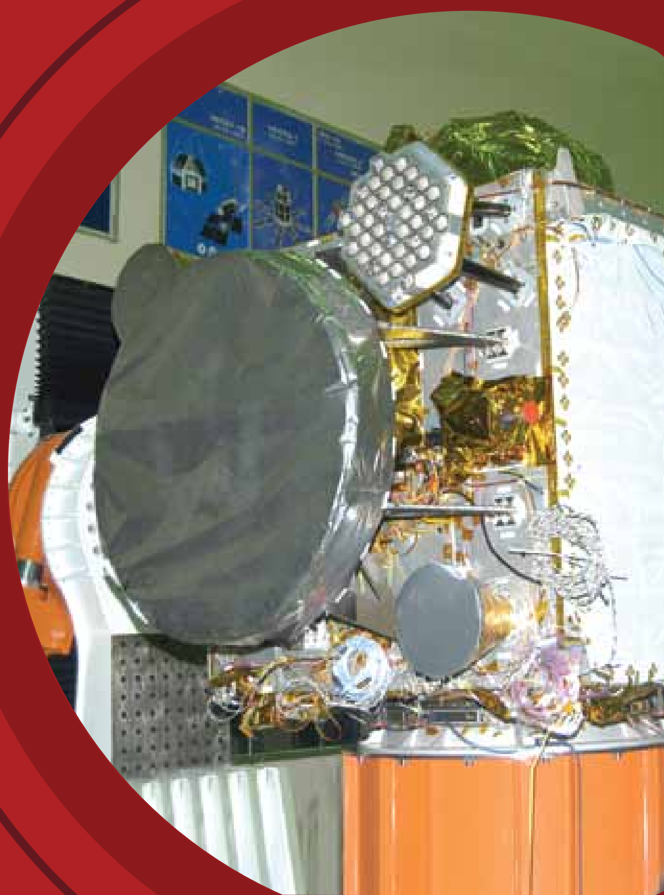
ORBIT	:	Geosynchronous, at 55 deg East longitude with 29 deg inclination
LIFT-OFF MASS	:	1425 kg
DRY MASS	:	614 kg
PHYSICAL DIMENSIONS	:	1.58 metre x 1.50 metre x 1.50 metre
POWER	:	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	:	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	:	Zero momentum system, orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	:	Ten years



IRNSS-1A Disassembled View

PAYLOADS

IRNSS-1A carries two types of payloads - navigation payload and ranging payload. The navigation payload of IRNSS-1A will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1A consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1A also carries Corner Cube Retro Reflectors for laser ranging.



IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is its primary service area. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East.

IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS consists of a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring and time keeping.

ISRO Navigation Centre (INC) at Byalalu, is the nerve center of the IRNSS Ground Segment. INC primarily generates navigation parameters

IRNSS Range and Integrity Monitoring Stations (IRIMS) perform continuous one way ranging of the IRNSS satellites and are also used for integrity determination of the IRNSS constellation.

IRNSS CDMA Ranging Stations(IRCDR) carry out precise two way ranging of IRNSS satellites.

IRNSS Network Timing Centre(IRNWT) at Byalalu generates, maintains and distributes IRNSS Network Time.

Spacecraft Control Facility (SCF) controls the space segment through Telemetry Tracking & Command networks. In addition to the regular TT&C operations, IRSCF also uplinks the navigation parameters generated by the INC.

IRNSS Data Communication Network(IRDCN) provides the required digital communication backbone to IRNSS network.

Laser Ranging Stations (ILRS) is planned to be used periodically to calibrate the IRNSS orbit determined by the other techniques

Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers

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Publications and Public Relations, ISRO Headquarters, Antariksh Bhavan
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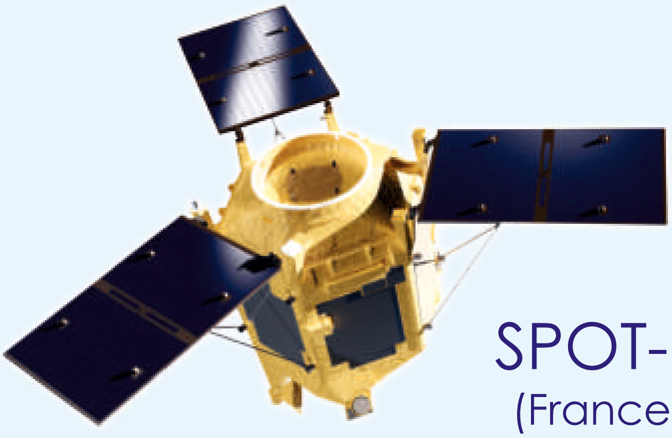
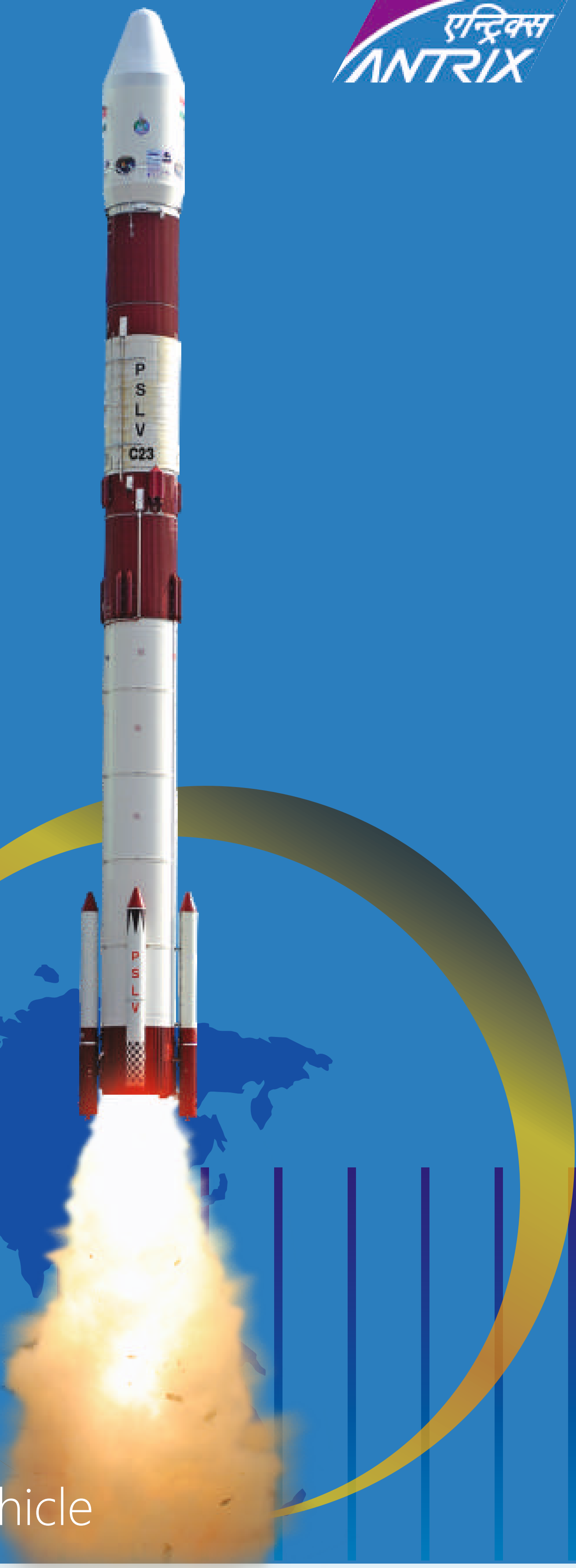
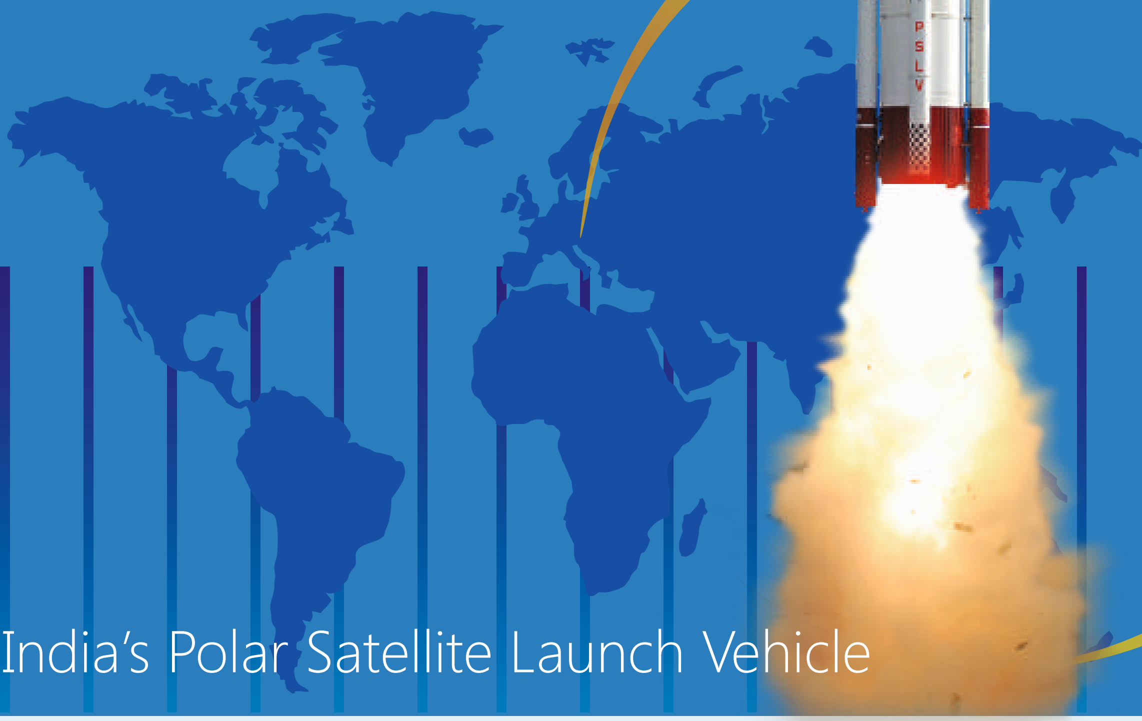
Design: Ideaworks.in
Printed by: M/s. Brilliant Printers Pvt. Ltd., B'lore-94

PSLV-C23

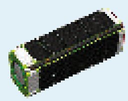


SPOT-7
(France)





India's Polar Satellite Launch Vehicle

AISAT	NLS7.1 (Can-X4)	NLS7.2 (Can-X5)	VELOX-1
			
GERMANY	CANADA	CANADA	SINGAPORE

PSLV-C23

PSLV-C23 at First Launch Pad

India's Polar Satellite Launch Vehicle, in its twenty seventh flight (PSLV-C23), will launch SPOT-7, a French earth observation satellite, into a 655 km Sun Synchronous Orbit (SSO). PSLV-C23 will be launched from Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota, from the First Launch Pad and it will be the tenth flight of PSLV in 'core-alone' configuration (without the use of solid strap-on motors).

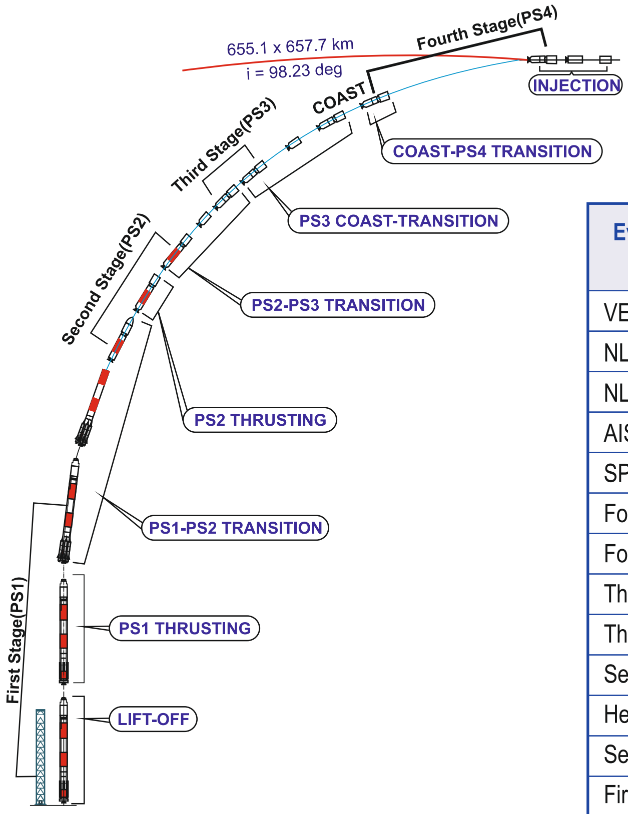
Along with SPOT-7, there will be four co-passenger satellites, viz., AISAT from DLR Germany, NLS7.1 and NLS7.2 from UTIAS/SFL Canada and VELOX-1 from NTU Singapore.

PSLV-C23 at a glance (Vehicle lift-off Mass: 230 tonne Height: 44.4 m)

	Stage-1	*Stage-2*	*Stage-3*	*Stage-4*
Nomenclature	PS1	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid UH25 + N_2O_4	Solid (HTPB based)	Liquid (MMH + MON-3)
Mass (tonne)	138	42	7.6	2.5
Max Thrust (kN)	4787	804	242	7.3 x 2
Burn Time (s)	102	148	110	526
Stage Dia (m)	2.8	2.8	2.0	2.8
Stage Length (m)	20	12.8	3.6	3.0

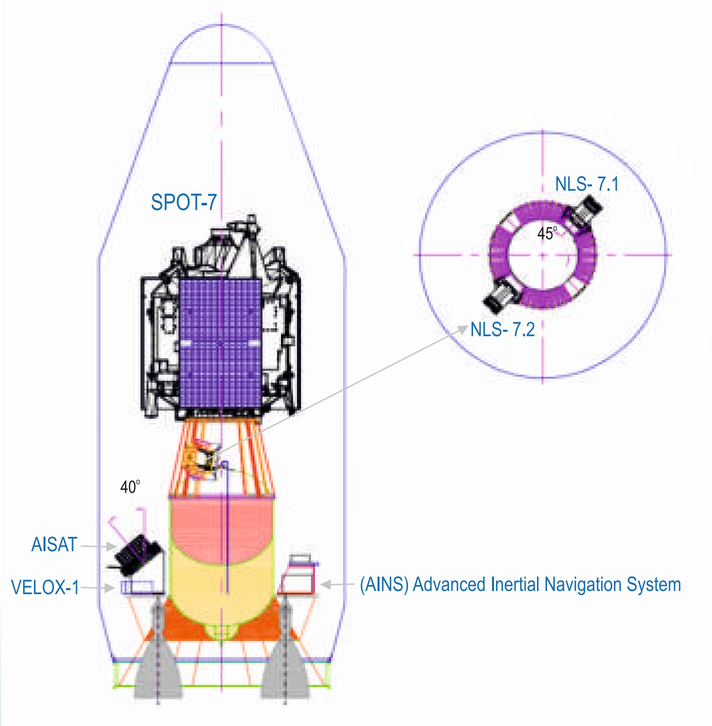
HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C23



Event Name	Time after lift-off (second)	Altitude (kilometre)	Velocity (metres/second)
VELOX-1 Separation	1198.7	662.3	7526.7
NLS7.2 Separation	1173.7	661.8	7526.9
NLS7.1 Separation	1143.7	661.2	7527.1
AISAT Separation	1113.7	660.6	7527.4
SPOT-7 Separation	1073.7	659.8	7527.7
Fourth Stage Cut-off	1036.7	659.1	7521.0
Fourth Stage Ignition	531.2	545.6	5331.0
Third Stage Separation	521.2	536.8	5344.6
Third Stage Ignition	263.4	220.2	3567.9
Second Stage Separation	262.2	218.7	3572.0
Heat Shield Separation	187.7	131.5	2256.8
Second Stage Ignition	110.8	52.9	1554.3
First Stage Separation	110.6	52.7	1555.4
First Stage Ignition	0.0	0.026	451.9

PSLV-C23 Typical Flight Profile



Satellites Mounting configuration

PSLV-C23 First Stage assembly

Primary Satellite

SPOT-7

AIRBUS DEFENCE & SPACE - FRANCE

SPOT-7 is a French optical Earth Observation Satellite identical to SPOT-6 launched earlier on-board PSLV-C21 during September 2012. SPOT-7, after its injection into Sun Synchronous Orbit, will be phased and placed diametrically opposite to SPOT-6 and will form part of the existing earth observation constellation. SPOT-7 satellite is built by AIRBUS DEFENCE & SPACE, a leading European space technology company.

SPOT-7 in clean room

SPOT-7 Salient features

Satellite mass	714 Kg
Orbit (Sun Synchronous Orbit)	655 km (Nominal)
Inclination	98.23 degree
Local time of descending node	09 hrs 58 min
Imaging Resolution	2.2 m Panchromatic, 8.8 m Multi-Spectral (Blue, Green, Red, NIR)
Swath width	60 km
Power	Battery – 2 Li- Ion; Solar panel – 3, 1450 Watt
Propulsion	Hydrazine Thrusters
Attitude control	Magnetic torquers, Control Momentum Gyros, Propulsion
Mission life	10 years

International Customer Satellites

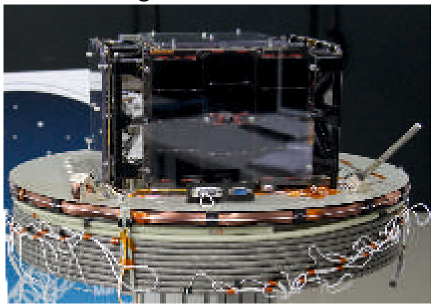
Co-passenger Satellites

AISAT
DLR Germany

Mission objectives

Global sea-traffic monitoring system with special emphasis on high traffic zones using AIS signals. First DLR Satellite in the nano-satellite class.

AISAT :14 kg

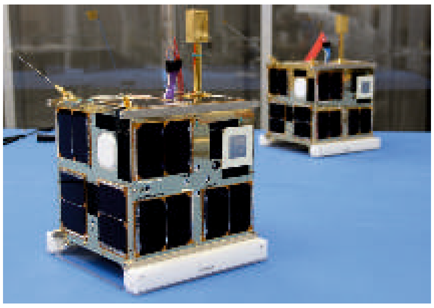


NLS7.1 (CAN-X4) & NLS7.2 (CAN-X5)
UTIAS/SFL Canada

Mission objectives

Two-spacecraft Precision Formation Flying using differential GPS with cm-level relative position and sub-metre level accurate position control system.

NLS7.1 :15kg



NLS7.2 :15kg

VELOX-1
NTU Singapore

Mission objectives

Technology demonstrator for in-house design of image sensor, MEMS-based attitude determination and control system, inter-satellite RF link.

VELOX-1 :7kg

Satellites of other countries launched by PSLV

SL. NO.	NAME	COUNTRY	DATE OF LAUNCH	MASS (kg)	LAUNCH VEHICLE
1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
13	COMPASS-I	GERMANY	28-04-2008	3	PSLV-C9
14	SEEDS	JAPAN	28-04-2008	3	PSLV-C9
15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17	CUBESAT-1	GERMANY	23-09-2009	1	PSLV-C14
18	CUBESAT-2	GERMANY	23-09-2009	1	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21	RUBIN-9.1	GERMANY	23-09-2009	1	PSLV-C14
22	RUBIN-9.2	GERMANY	23-09-2009	1	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT 6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32	NLS8.1	AUSTRIA	25-02-2013	14	PSLV-C20
33	NLS8.2	AUSTRIA	25-02-2013	14	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UK	25-02-2013	6.5	PSLV-C20

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Antrix Corporation Limited
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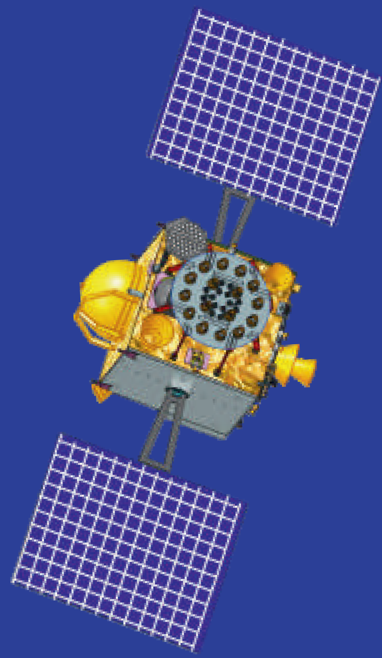
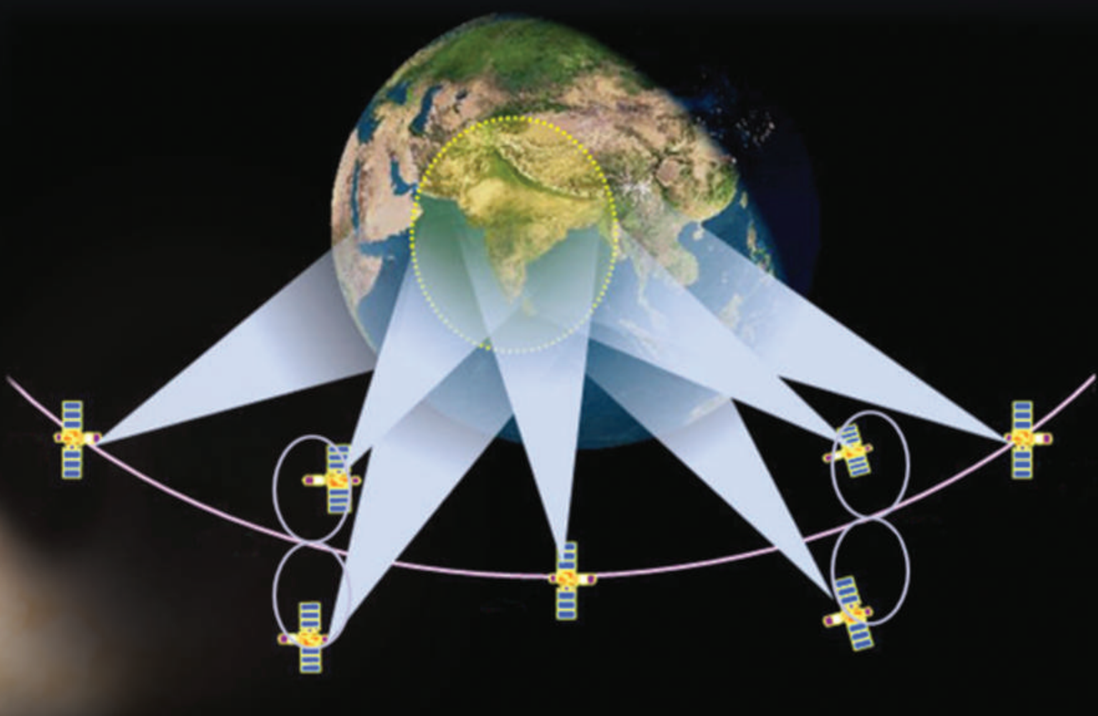
June 2014 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore



PSLV-C24

IRNSS-1B



PSLV-C24


PSLV-C24 Carrying IRNSS-1B at the first Launch pad

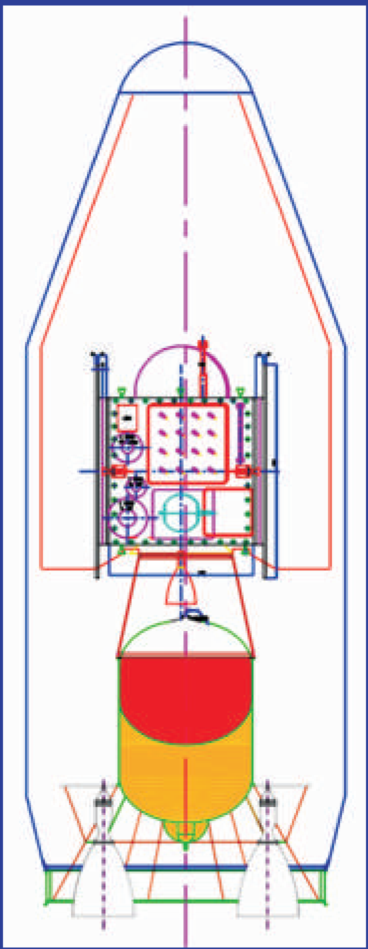
Polar Satellite Launch Vehicle, in its twenty sixth flight (PSLV-C24), will launch IRNSS-1B, the second satellite of the Indian Regional Navigation Satellite System (IRNSS). The launch will take place from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. PSLV-C24 will use 'XL' version of PSLV. This is the sixth time 'XL' configuration is being flown, earlier five being PSLV-C11/Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/RISAT-1, PSLV-C22/IRNSS-1A and PSLV-C25/Mars Orbiter Spacecraft missions.

PSLV-C24 AT A GLANCE

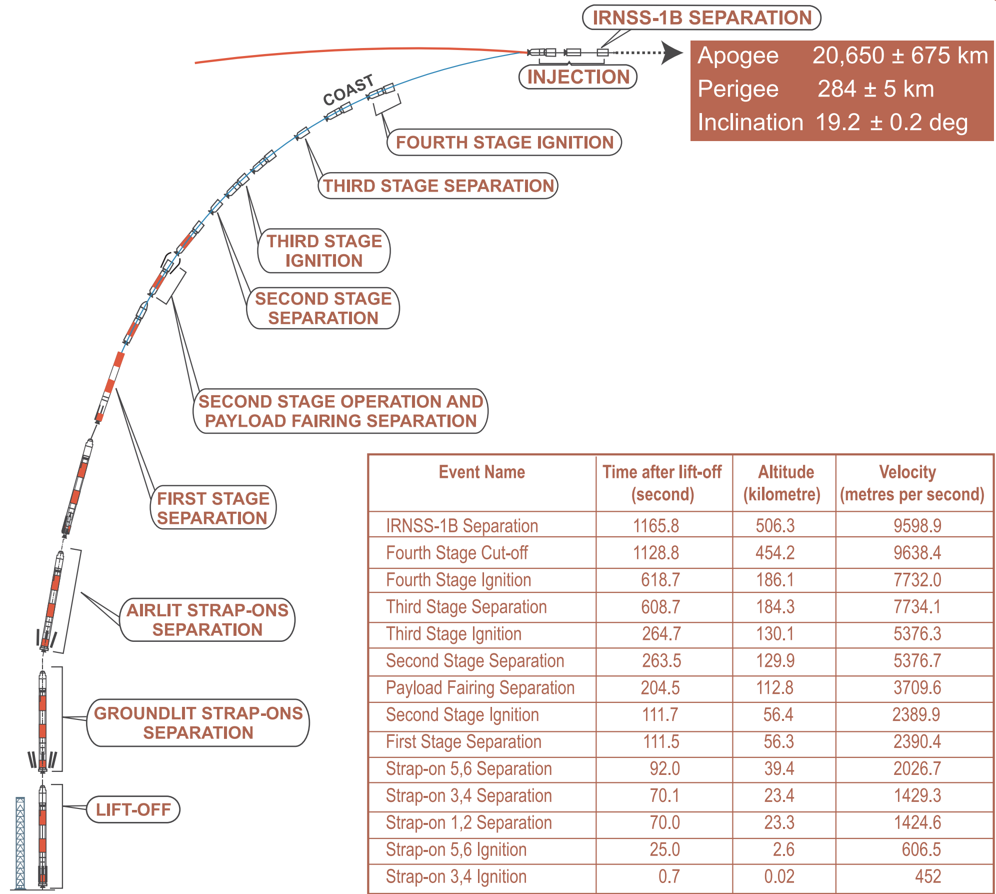
Lift-off Mass: 320 tons Height: 44.4 metres

	Stage-1	*Stage-2*	*Stage-3*	*Stage-4*
Nomenclature	Core Stage PS1+ 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Mass (T)	138 (Core), 6 x 12 (Strap-on)	41.7	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
Burn Time (s)	101.5 (Core), 49.5 (Strap-on)	149	112.1	513
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	2.8
Stage Length (m)	20 (Core), 14.7 (Strap-on)	12.5	3.6	2.6

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen



IRNSS-1B in PSLV-C24 Envelope



Event Name	Time after lift-off (second)	Altitude (kilometre)	Velocity (metres per second)
IRNSS-1B Separation	1165.8	506.3	9598.9
Fourth Stage Cut-off	1128.8	454.2	9638.4
Fourth Stage Ignition	618.7	186.1	7732.0
Third Stage Separation	608.7	184.3	7734.1
Third Stage Ignition	264.7	130.1	5376.3
Second Stage Separation	263.5	129.9	5376.7
Payload Fairing Separation	204.5	112.8	3709.6
Second Stage Ignition	111.7	56.4	2389.9
First Stage Ignition	111.5	56.3	2390.4
Strap-on 5,6 Separation	92.0	39.4	2026.7
Strap-on 3,4 Separation	70.1	23.4	1429.3
Strap-on 1,2 Separation	70.0	23.3	1424.6
Strap-on 5,6 Ignition	25.0	2.6	606.5
Strap-on 3,4 Ignition	0.7	0.02	452
Strap-on 1,2 Ignition	0.5	0.02	452
First Stage Ignition	0.0	0.02	452

PSLV-C24 TYPICAL FLIGHT PROFILE

PSLV-C24 Second Stage in the Stage Prepartion Facility

PSLV-C24 Third and Fourth Stages

PSLV-C24 in the Mobile Service Tower prior to Satellite Integration

IRNSS-1B

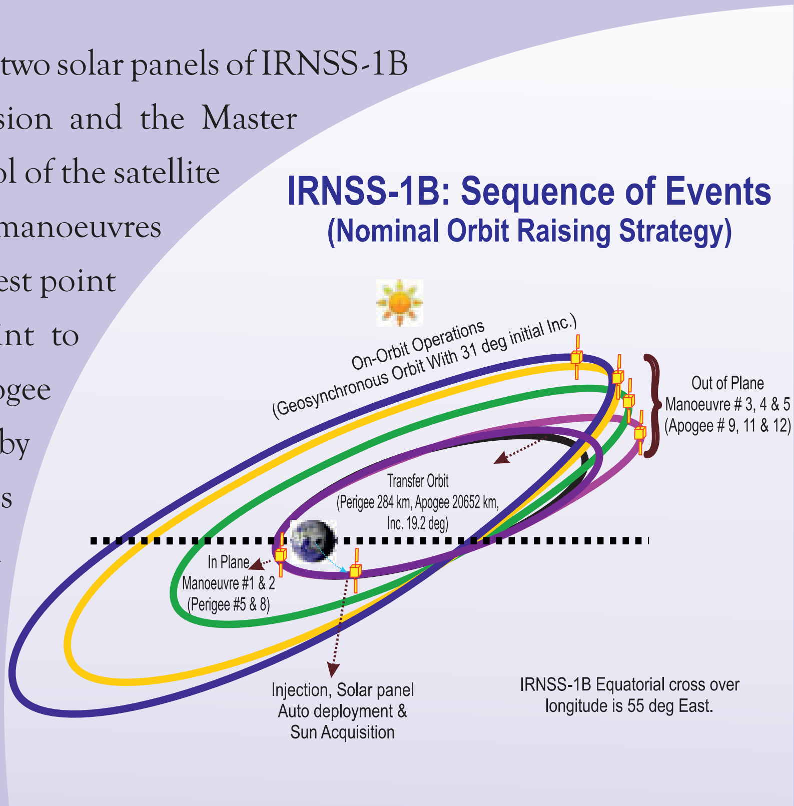
IRNSS-1B is the second navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessor, IRNSS-1A, was launched by PSLV-C22 in July 2013. IRNSS-1B has a lift-off mass of 1432 kg. The configuration of IRNSS-1B is similar to that of IRNSS-1A. The satellite has been realised in less than seven months after the launch of its predecessor.

The two solar panels of IRNSS-1B consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1B maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.


IRNSS-1B undergoing vibration test

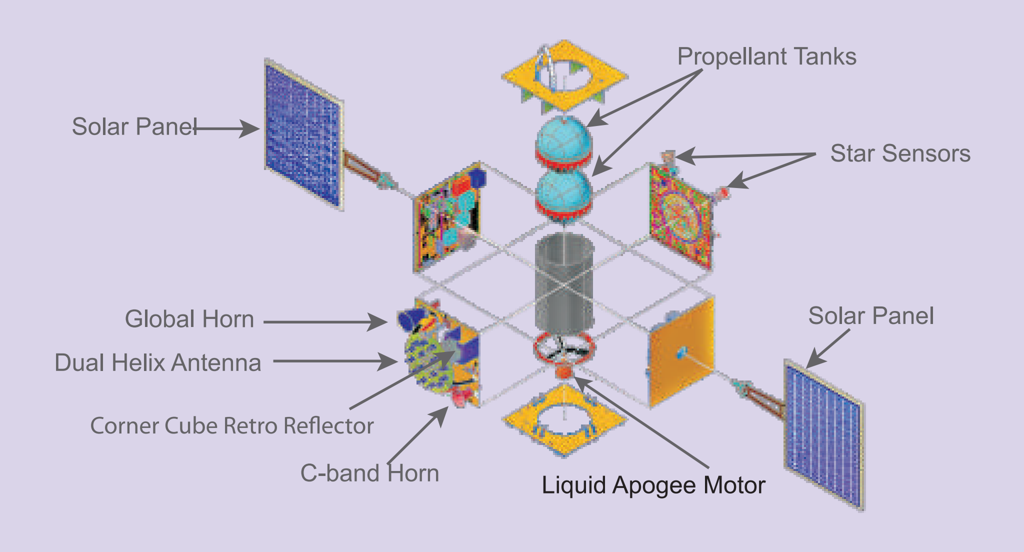
IRNSS-1B will be launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 20,652 km apogee (farthest point to Earth) with an inclination of 19.2 deg with respect to the equatorial plane.

After injection into this preliminary orbit, the two solar panels of IRNSS-1B are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of two manoeuvres at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the circular geosynchronous orbit at 55 deg East location with an initial inclination of 31 deg with respect to the equator.

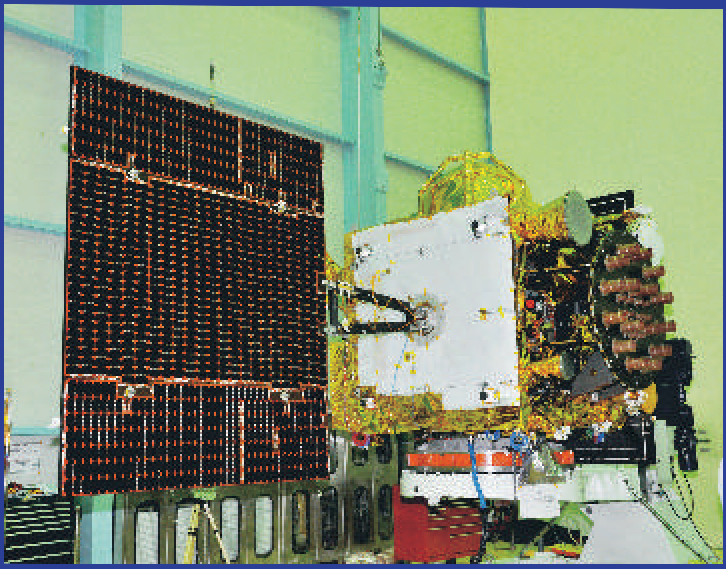


IRNSS-1B Salient Features:

ORBIT	: Geosynchronous, at 55 deg East longitude with 29 deg inclination
LIFT -OFF MASS	: 1432 kg
DRY MASS	: 614 kg
PHYSICAL DIMENSIONS	: 1.58 metre x 1.50 metre x 1.50 metre
POWER	: Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	: 440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	: Zero momentum system: orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	: Ten years



IRNSS-1B Disassembled View



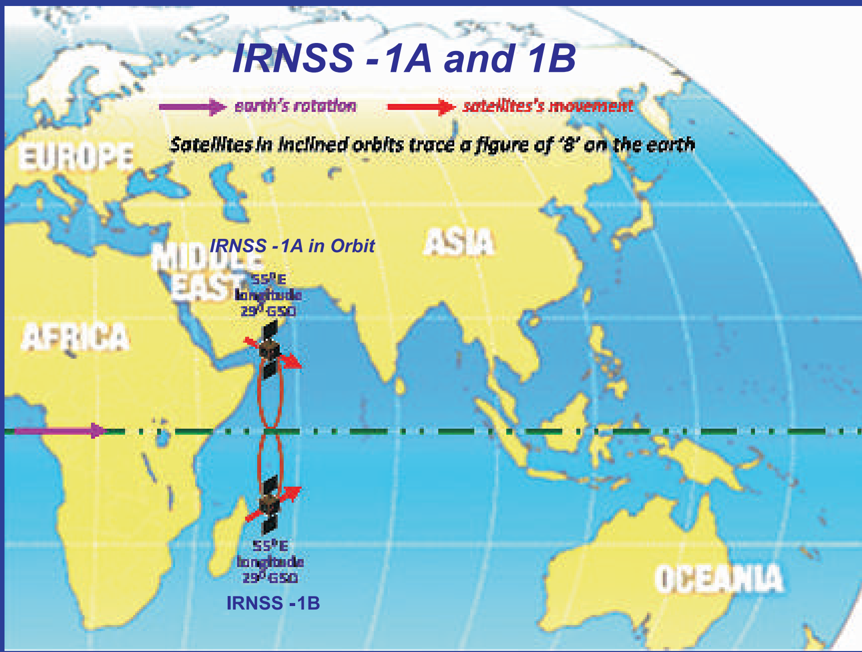
IRNSS-1B at clean room with one of its solar panels deployed

PAYLOADS:

IRNSS -1B carries two types of payloads – navigation payload and ranging payload.The navigation payload of IRNSS-1B will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1B consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1B also carries Corner Cube Retro Reflectors for laser ranging.

IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is the primary service area of IRNSS. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East.



IRNSS will provide two types of services, namely, Standard Positioning Service (SPS) which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS comprises of a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS-1A, the first satellite of the IRNSS constellation, has already started functioning from its designated orbital slot after extensive on orbit test and evaluation to confirm its satisfactory performance.

IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.

The constituent elements of the IRNSS ground segment are:

- ISRO Navigation Centre (INC) at Byalalu, is the nerve center of the IRNSS Ground Segment. INC primarily generates navigation parameters.
- IRNSS Range and Integrity Monitoring Stations (IRIMS) perform continuous one way ranging of the IRNSS satellites and are also used for integrity determination of the IRNSS constellation.
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Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Disaster Management
- Vehicle tracking and fleet management
- Integration with mobile phones
- Precise Timing
- Mapping and Geodetic data capture
- Terrestrial navigation aid for hikers and travellers
- Visual and voice navigation for drivers

Indian Space Research Organisation
Publications and Public Relations, ISRO Headquarters, Antariksh Bhavan
New BEL Road, Bangalore - 560 231, India www.isro.gov.in

March 2014 Design: smartw@gmail.com
Printed by: M/s. Aditya Printers, Bangalore

PSLV-C25/Mars Orbiter Mission

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PSLV PROJECT

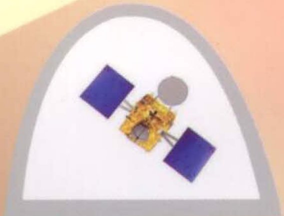
INDIAN SPACE RESEARCH ORGANISATION

25th PSLV Mission

PSLV-XL Missions Heritage

PSLV-C11
CHANDRAYAAN-1 Mission

First Lunar Mission of India



PSLV-C17
GSAT-12 Mission

Dedicated Communication Satellite

PSLV-C19
RISAT-1 Mission

Heaviest Satellite ever launched by PSLV

PSLV-C22
IRNSS-1A Mission

First Regional Navigation Satellite

MISSION	SPACECRAFT	SPACECRAFT MASS	ORBIT	LAUNCH DATE
PSLV-C11	Chandrayaan-1	1380 kg	255 km x 22860 km	22-10-2008
PSLV-C17	GSAT-12	1410 kg	284 km x 21000 km	15-07-2011
PSLV-C19	RISAT-1	1858 kg	480 km (SSPO)	26-04-2012
PSLV-C22	IRNSS-1A	1426 kg	284 km x 20650 km	01-07-2013

PSLV-C25/Mars Orbiter Mission

PSLV-C25, the 25th mission of PSLV and 5th in the XL configuration, will carry the Mars Orbiter Satellite (1337 kg) into a 250 km x 23500 km elliptical orbit. The Satellite will be further navigated to a hyperbolic departure trajectory and thereafter it traverses an interplanetary cruise trajectory before reaching the intended orbit around the Mars.

Challenges......

The major technical challenges for the Launch Vehicle in accomplishing this Mission arise from the larger Argument of Perigee (AOP) requirement ranging from 276.4° to 288.6° compared to 178° in earlier Missions. This AOP minimises the energy required in transferring the satellite from the Earth to the Mars. In this regard, the Launch Vehicle flight regime is extended to 2657s (against 1200s for regular PSLV Missions) with a long coasting (1580-1800s) before the ignition of the PS4 stage. The long coasting necessitated specific modification and validation of the coast phase guidance algorithm, on-board battery capacity augmentation, assessment on the performance of inertial systems for extended flight duration and deployment of two Ship-borne Terminals to capture the critical telemetry data during flight in the non-visibility zone.

Additional provisions are made for the thermal management of Vehicle Equipment Bay, PS4 stage and also the Spacecraft elements considering the longer exposure to extreme cold space.

Another unique task associated with management of this Mission is the generation and Configuration Control of multiple Initialization files for the on-board computers corresponding to the different launch dates.

PSLV-C25 Vehicle Characteristics	
Vehicle Height	44.4 m
Lift off Mass	320 t
Propulsion Stages	
First Stage	6PSOM-XL+S139
Second Stage	PL40
Third Stage	HPS3
Fourth Stage	L2.5
Payload Fairing	3.2 m dia

Mission Specifications	
Apogee	23500 ±675 km
Perigee	250 ±5 km
Argument of Perigee	282.55 ± 0.2° (For Launch on 5th November, 2013)
Inclination	19.2 ± 0.2°
Payload Mass	1337 kg

Polar Satellite Launch Vehicle

PSLV-C25 Vehicle Configuration

The Polar Satellite Launch Vehicle (PSLV) caters to the requirements of launching satellites into Sun-Synchronous and Low Earth Orbits. PSLV is a four stage vehicle with alternate Solid and Liquid propulsion stages. The booster stage along with the strap-on motors and the third stage are solid motors while the second and fourth stages use liquid engines.

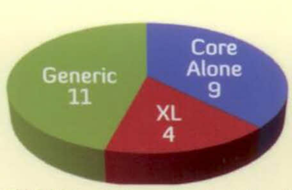
PSLV has the capability to launch 1750 kg class satellites into 600 km Sun-Synchronous Polar Orbit (SSPO) and 1425 kg satellites into Sub-Geosynchronous Transfer Orbit (Sub GTO) of 284 km X 21000 km. The vehicle has provision to launch multiple satellites.

PSLV has successfully accomplished 2 developmental and 21 operational Missions in a row. It has established itself as a work horse operational launcher of ISRO and has a demonstrated reliability of 0.96. Currently two variants of PSLV are operational, namely PSLV-XL (with six extended strap-on motors attached to the first stage) and PSLV-Core Alone (without strap-on motors). PSLV-C25/Mars Orbiter Mission employs the PSLV-XL version which has already been used in four earlier Missions.

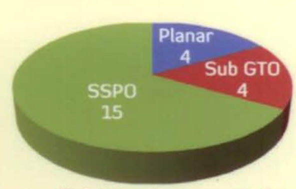
PSLV-XL: Stages at a Glance

	Stage 1	PSOM-XL	Stage 2	Stage 3	Stage 4
Length (m)	20	12	12.8	3.6	2.7
Diameter (m)	2.8	1	2.8	2	2.8
Propellant	Solid (HTPB based)	Soild (HTPB based)	Liquid (UH25+N_2O_4)	Solid (HTPB based)	Liquid (MMH+MON3)
Propellant Mass (t)	138	12.2	42	7.6	2.5
Peak Thrust (kN)	4800	719	799	247	7.3x2
Burn Time (s)	103	50	148	112	525

23 Successive Successful Missions Accomplished

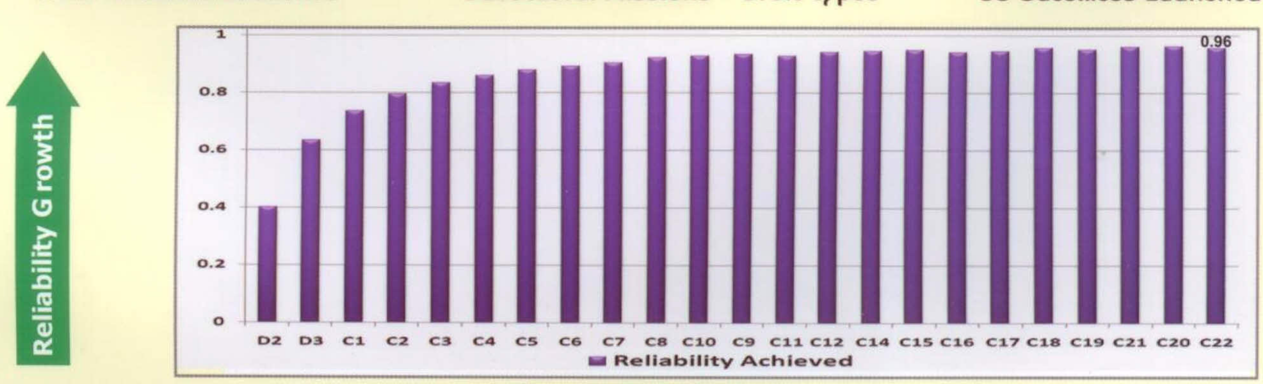


PSLV Variants Launched



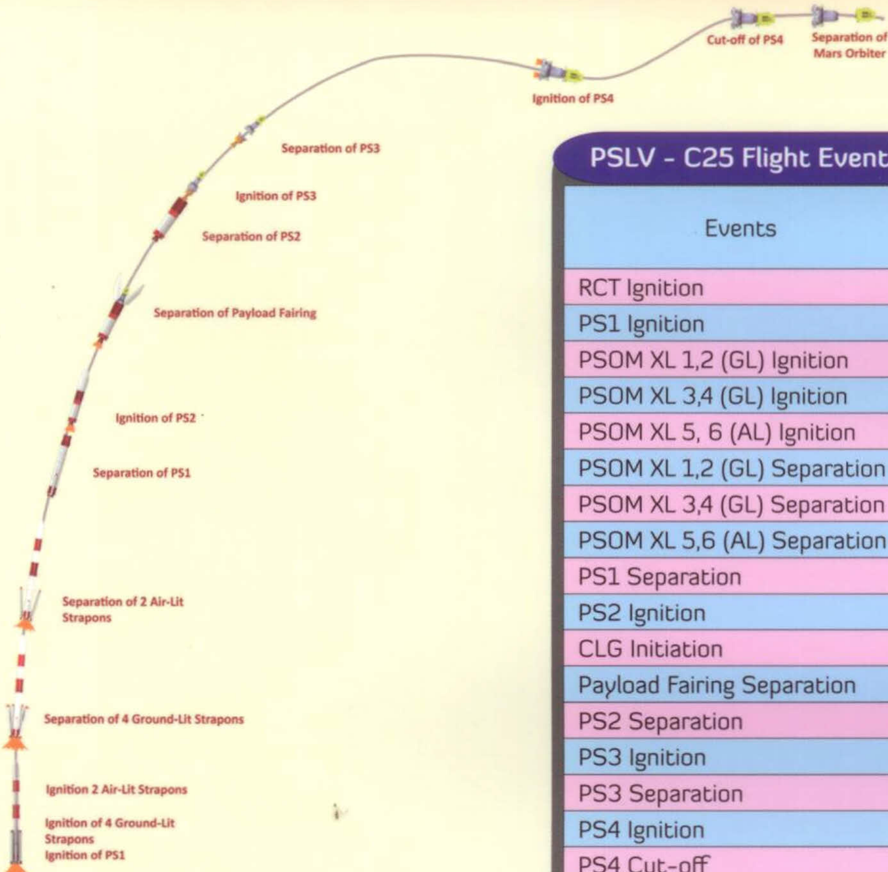
Successful Missions - Orbit types

63 Satellites Launched



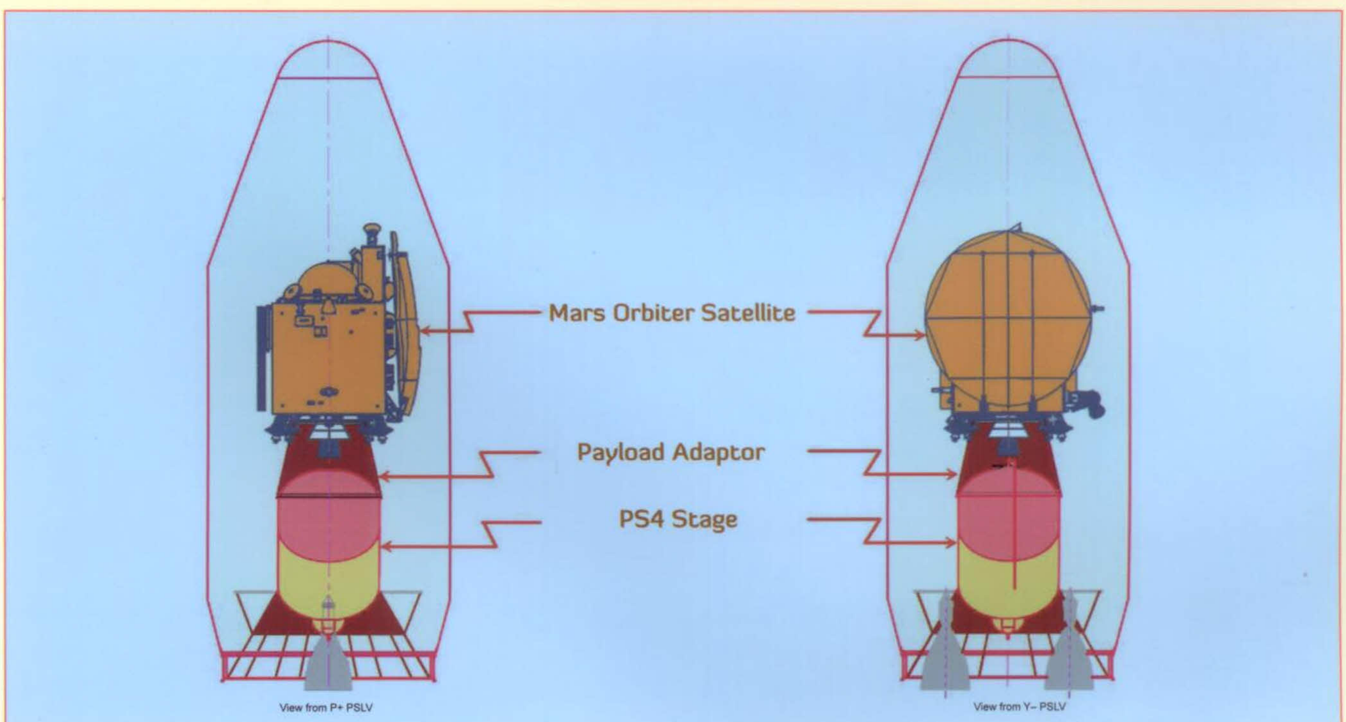
Demonstrated Reliability

PSLV-C25 Flight Sequence



PSLV - C25 Flight Events for Launch on 5th Nov. 2013

Events	Time (s)	Local Altitude (km)	Inertial Velocity (m/s)
RCT Ignition	-3.00	0.024	451.89
PS1 Ignition	0.00	0.024	451.89
PSOM XL 1,2 (GL) Ignition	0.46	0.024	451.89
PSOM XL 3,4 (GL) Ignition	0.66	0.024	451.89
PSOM XL 5, 6 (AL) Ignition	25.04	2.670	611.52
PSOM XL 1,2 (GL) Separation	69.94	23.489	1431.80
PSOM XL 3,4 (GL) Separation	70.14	23.618	1436.54
PSOM XL 5,6 (AL) Separation	92.04	39.704	2024.36
PS1 Separation	112.75	57.678	2387.67
PS2 Ignition	112.95	57.846	2387.16
CLG Initiation	117.95	61.955	2415.46
Payload Fairing Separation	201.75	113.169	3624.69
PS2 Separation	264.74	132.311	5379.33
PS3 Ignition	265.94	132.531	5378.94
PS3 Separation	583.60	194.869	7730.88
PS4 Ignition	2100.50	271.317	7642.04
PS4 Cut-off	2619.72	342.515	9833.49
Mars Orbiter Separation	2656.72	383.388	9804.01



Payload Accommodation in PSLV-C25

Mars Orbiter

Mars Orbiter Mission is ISRO's first Interplanetary Mission with an Orbiter craft designed to orbit Mars in an elliptical orbit of 366 km x 80000 km. The technological objective of the Mission is to design and realize a spacecraft with a capability to perform Earth Bound Manoeuvre, Martian Transfer Trajectory (MTT) and Mars Orbit Insertion (MOI) phases.

Mars Orbiter

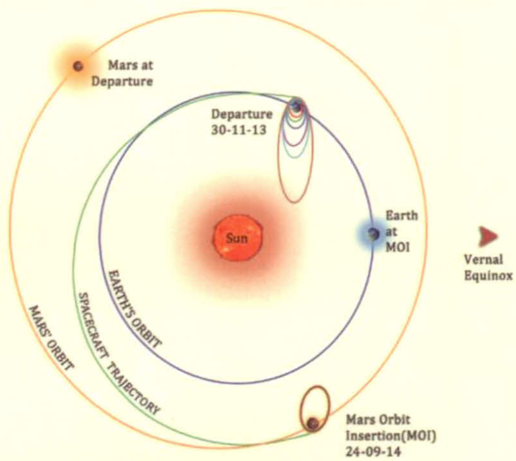
Technological Objectives

- To develop the technologies required for design, planning, management, deep space communication and operations of an Interplanetary Mission.
- To design and realize Mars Orbiter with a capability to survive and perform Earth bound Manoeuvres, cruise phase of 300 days, Mars orbit insertion & captu re, and on-orbit phase around Mars.
- Incorporate autonomous features to handle contingency situations.

Payloads

- Lyman Alpha Photometer (LAP)
- Methane Sensor for Mars (MSM)
- Martian Exospheric Neutral Composition Explorer (MENCA)
- Mars Colour Camera (MCC)
- TIR Imaging Spectrometer (TIS)

The scientific objectives of these payloads are exploration of Mars surface features, morphology, mineralogy and Martian atmosphere.



Trajectory Design

Reaching Mars........

The Earth-Mars transition comprises the following three phases

- Earth-centered phase
- Heliocentric phase
- Martian phase

The Spacecraft is injected into an elliptical parking orbit by the launcher. After injection of the Mars Orbiter into the orbit, five orbit raising burns using Liquid Engine are planned. After these burns, the Orbiter will be given a Trans-Mars Injection (TMI) manoeuvre at perigee which will put the Spacecraft in the Mars Transfer Trajectory. After the end of the TMI, the Orbiter travels in a hyperbolic departure trajectory with which it escapes from the Earth's Sphere Of Influence (SOI). After crossing the Earth's SOI, the Spacecraft is in an elliptical interplanetary cruise trajectory around the sun for the planned transfer time after which it has its rendezvous with Mars. The spacecraft arrives at the Mars SOI in a hyperbolic trajectory. When the Orbiter reaches Periapsis, closest to Mars, it is manoeuvred for Mars Orbit Insertion (MOI), which will insert the Orbiter into an elliptical Martian orbit of 366 km x 80000 km .

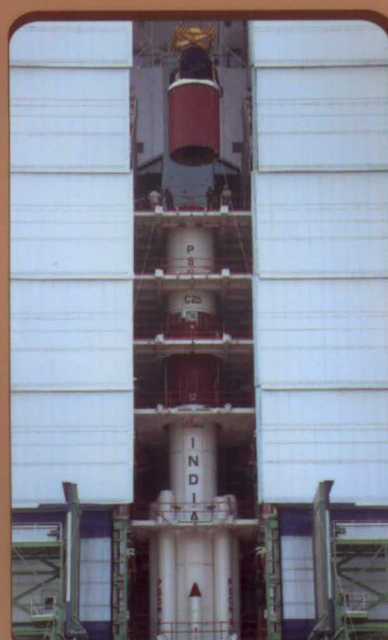
Glimpses of Pre-Launch Operations

CBS+NES Stacking

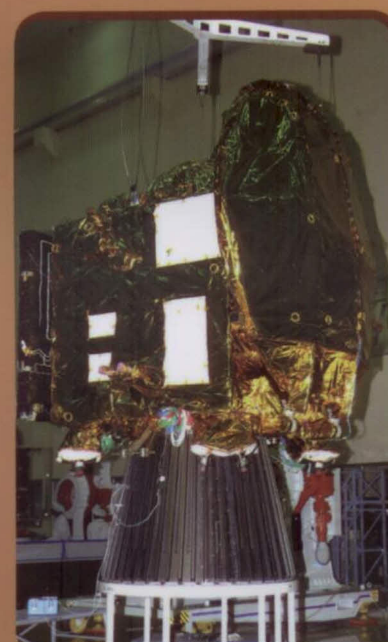
PSOM-XL Assembly

PS2 Stacking

PS3-PS4 Moduling

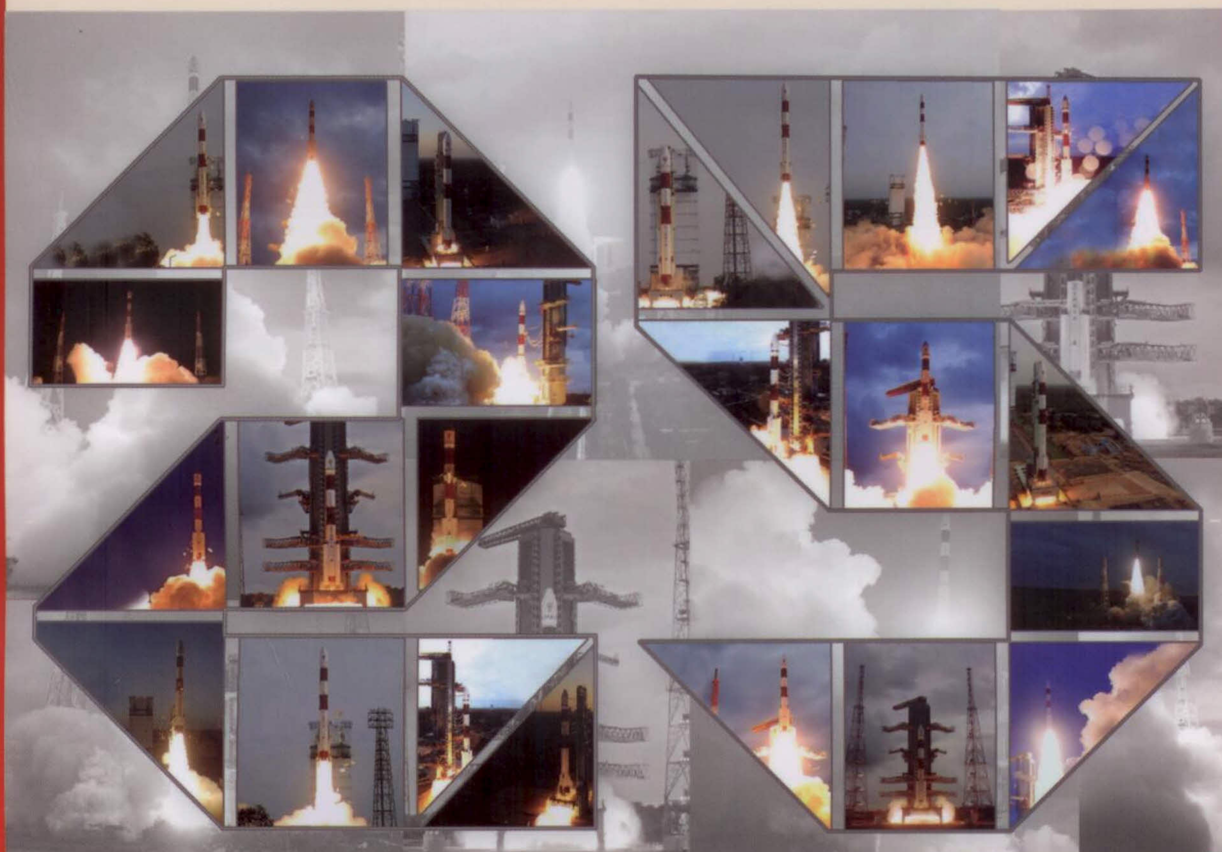


PS3-PS4 Module Stacking



Mars Orbiter Testing

PSLV Launches....



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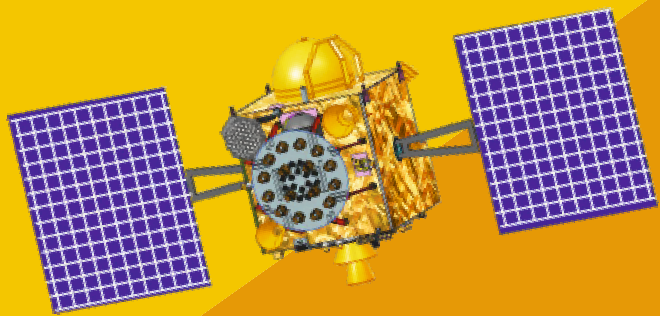
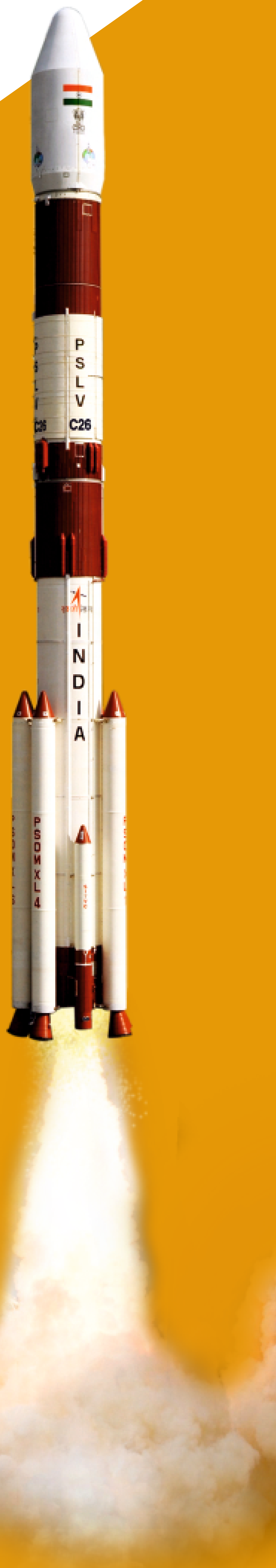


PSLV-C26/IRNSS-1C



PSLV-C26

PSLV-C26 at First Launch Pad

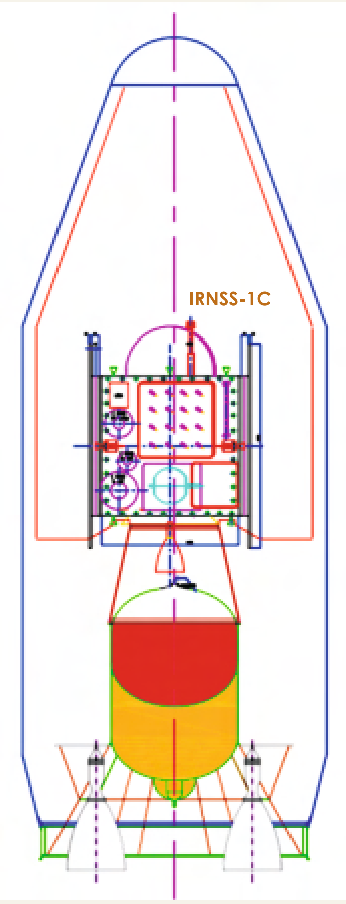
Polar Satellite Launch Vehicle, in its twenty eighth flight (PSLV-C26), will launch IRNSS-1C, the third satellite of the Indian Regional Navigation Satellite System (IRNSS). The launch will take place from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. PSLV-C26 will use 'XL' version of PSLV. This is the seventh time 'XL' configuration is being flown, earlier six being PSLV-C11/Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/RISAT-1, PSLV-C22/IRNSS-1A, PSLV-C25/Mars Orbiter Spacecraft and PSLV-C24/IRNSS-1B missions.

PSLV-C26 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

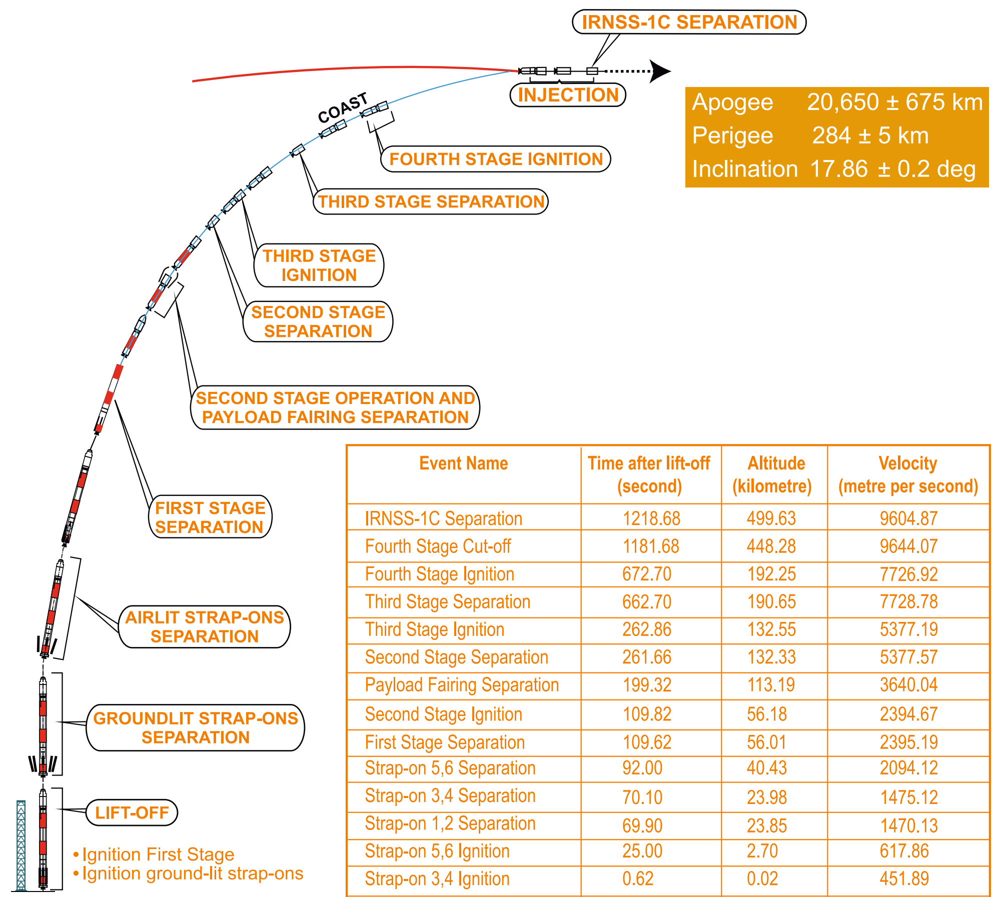
	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Mass (T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	2.8
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C26



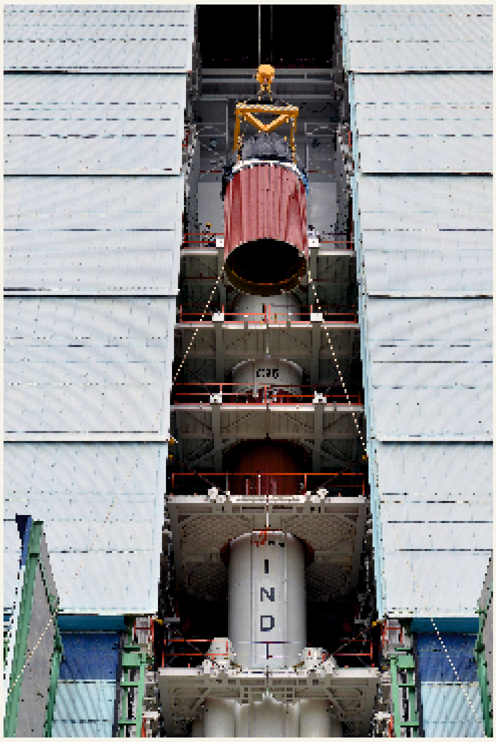
IRNSS-1C in PSLV-C26 Envelope



Event Name	Time after lift-off (second)	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1C Separation	1218.68	499.63	9604.87
Fourth Stage Cut-off	1181.68	448.28	9644.07
Fourth Stage Ignition	672.70	192.25	7726.92
Third Stage Separation	662.70	190.65	7728.78
Third Stage Ignition	262.86	132.55	5377.19
Second Stage Separation	261.66	132.33	5377.57
Payload Fairing Separation	199.32	113.19	3640.04
Second Stage Ignition	109.82	56.18	2394.67
First Stage Separation	109.62	56.01	2395.19
Strap-on 5,6 Separation	92.00	40.43	2094.12
Strap-on 3,4 Separation	70.10	23.98	1475.12
Strap-on 1,2 Separation	69.90	23.85	1470.13
Strap-on 5,6 Ignition	25.00	2.70	617.86
Strap-on 3,4 Ignition	0.62	0.02	451.89
Strap-on 1,2 Ignition	0.42	0.02	451.89
First Stage Ignition	0.0	0.02	451.89

PSLV-C26 Typical Flight Profile

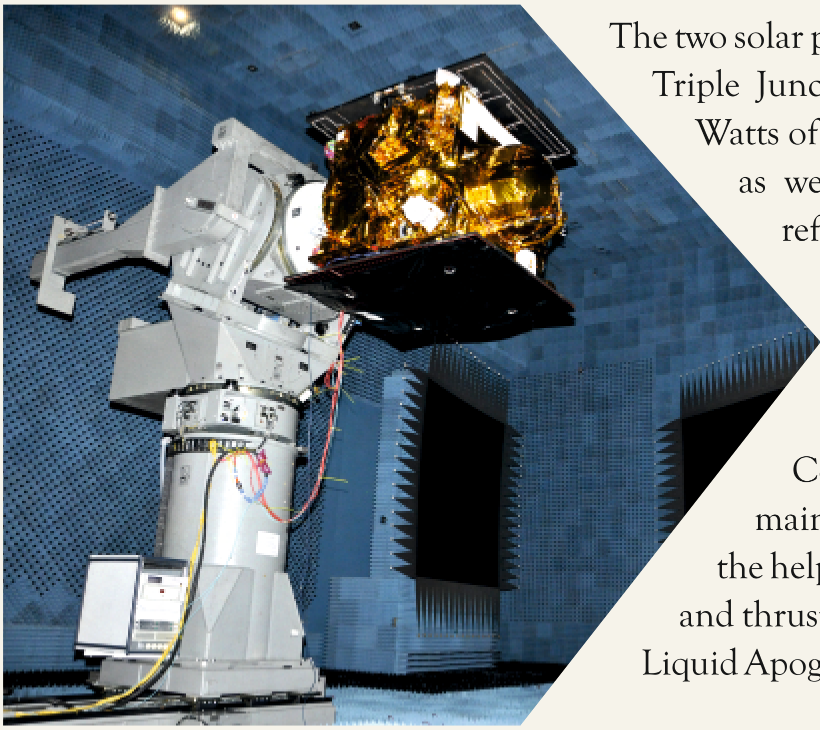
Nozzle End Segment of PSLV-C26 being hoisted for assembly



Assembly of PSLV-C26 Third and Fourth Stages

IRNSS-1C

IRNSS-1C is the third navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A and IRNSS-1B were launched by PSLV-C22 and PSLV-C24 in July 2013 and April 2014 respectively. IRNSS-1C has a lift-off mass of 1425.4 kg. The configuration of IRNSS-1C is similar to that of IRNSS-1A and IRNSS-1B. The satellite has been realised in less than six months after the launch of its predecessor.

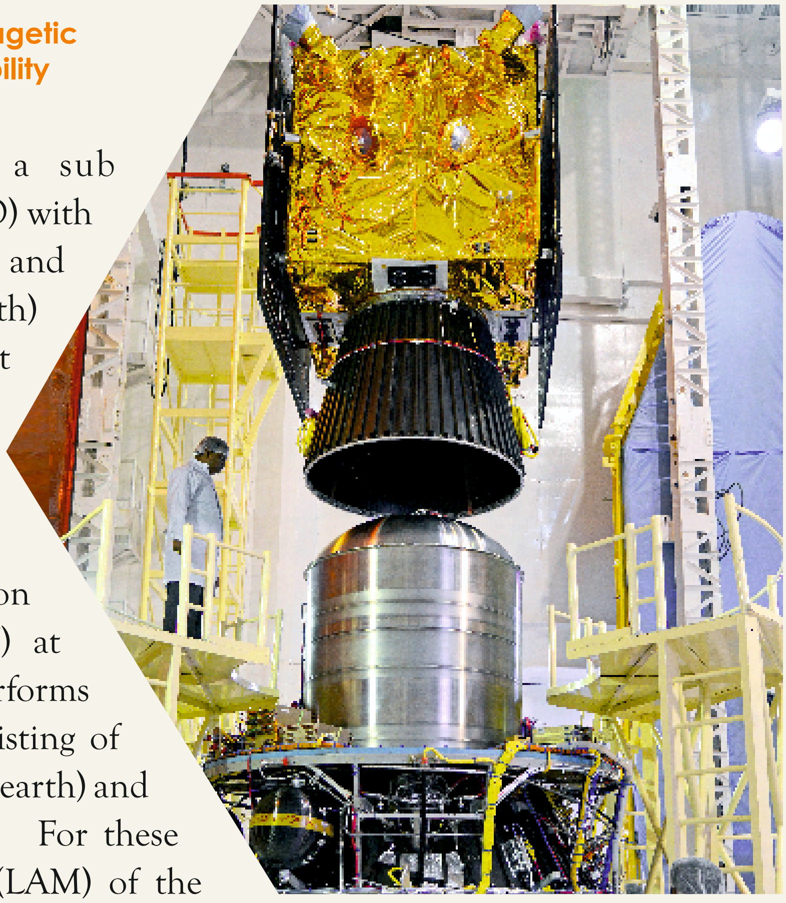


IRNSS-1C spacecraft undergoing Electro-Magetic Interference and Electro-Magetic Compatibility (EMI-EMC) tests

The two solar panels of IRNSS-1C consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1C maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.

IRNSS-1C will be launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 20,650 km apogee (farthest point to Earth) with an inclination of 17.86 deg with respect to the equatorial plane.

After injection into this preliminary orbit, the two solar panels of IRNSS-1C are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of one manoeuvre at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the circular geostationary orbit at its designated location.



IRNSS-1C spacecraft being assembled with PSLVC-26

IRNSS-1C Salient features

ORBIT	Geostationary, at 83 deg East longitude
LIFT-OFF MASS	1425.4 kg
DRY MASS	600.1 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
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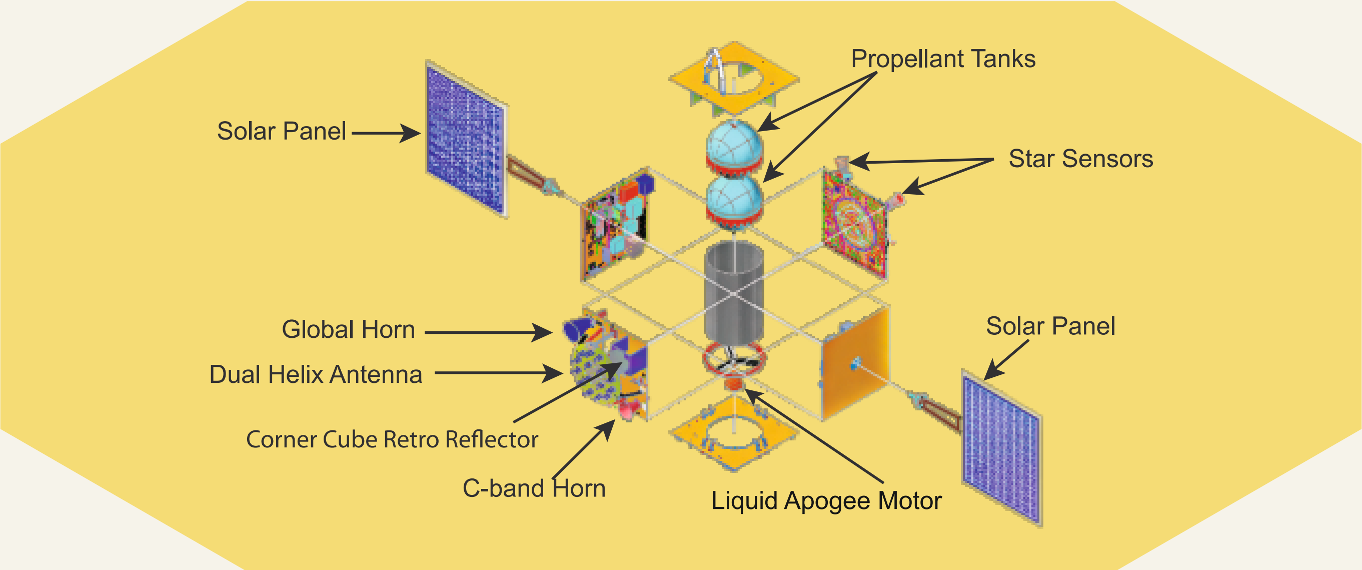

IRNSS-1C Disassembled View

PAYLOADS:

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- Vehicle tracking and fleet management
- Precise Timing
- Terrestrial navigation aid for hikers and travellers
- Disaster Management
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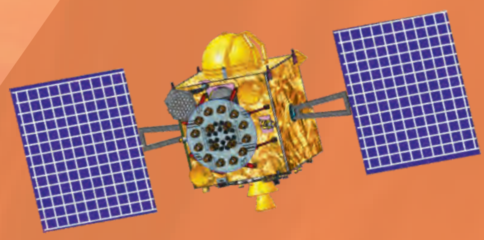
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers

Indian Space Research Organisation

Publications and Public Relations,
ISRO Headquarters, Antariksh Bhavan
New BEL Road, Bangalore - 560 231, India.
www.isro.gov.in

September 2014 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore

PSLV-C27
IRNSS-1D



PSLV-C27

PSLV-C27 at Second Launch Pad

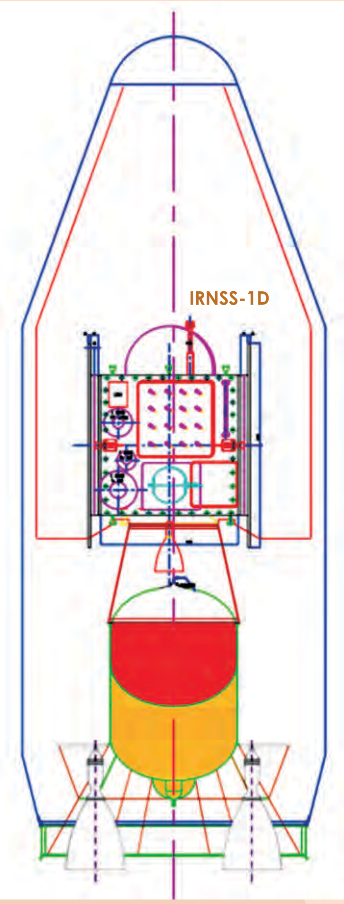
Polar Satellite Launch Vehicle, in its twenty ninth flight (PSLV-C27), will launch IRNSS-1D, the fourth satellite of the Indian Regional Navigation Satellite System (IRNSS). The launch will take place from the Second Launch Pad (SLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. As in the previous three launches of IRNSS satellites, PSLV-C27 will use 'XL' version of PSLV. This is the eighth time 'XL' configuration is being flown, earlier seven being PSLV-C11/Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/RISAT-1, PSLV-C22/IRNSS-1A, PSLV-C25/Mars Orbiter Spacecraft, PSLV-C24/IRNSS-1B and PSLV-C26/IRNSS-1C missions.

PSLV-C27 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

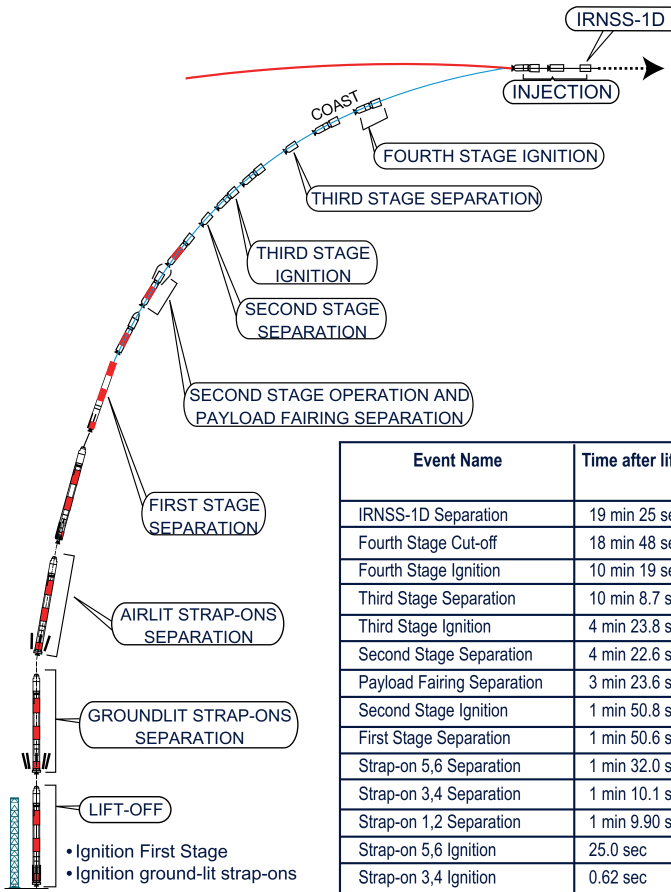
	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C27



IRNSS-1D in PSLV-C27 Envelope

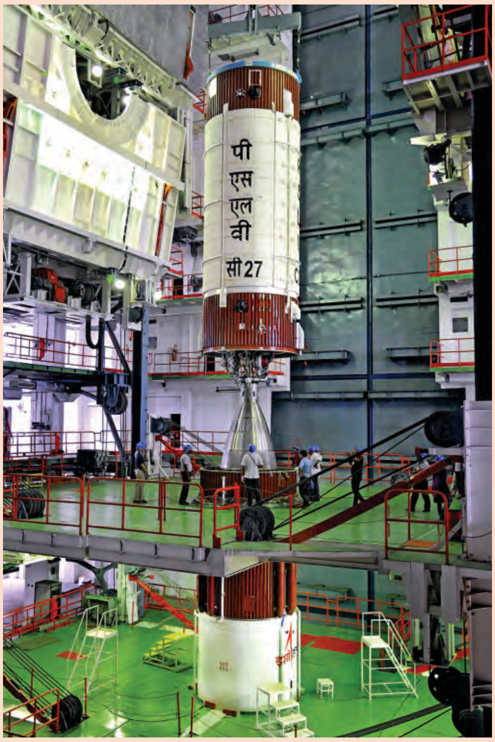


Apogee 20,650 ± 675 km
Perigee 284 ± 5 km
Inclination 19.2 ± 0.2 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1D Separation	19 min 25 sec	506.83	9598.39
Fourth Stage Cut-off	18 min 48 sec	454.63	9638.05
Fourth Stage Ignition	10 min 19 sec	186.43	7732.00
Third Stage Separation	10 min 8.7 sec	184.63	7734.17
Third Stage Ignition	4 min 23.8 sec	131.34	5377.04
Second Stage Separation	4 min 22.6 sec	131.10	5377.46
Payload Fairing Separation	3 min 23.6 sec	113.02	3712.24
Second Stage Ignition	1 min 50.8 sec	56.21	2391.98
First Stage Separation	1 min 50.6 sec	56.04	2392.48
Strap-on 5,6 Separation	1 min 32.0 sec	40.02	2073.68
Strap-on 3,4 Separation	1 min 10.1 sec	23.89	1472.12
Strap-on 1,2 Separation	1 min 9.90 sec	23.76	1467.11
Strap-on 5,6 Ignition	25.0 sec	2.71	619.69
Strap-on 3,4 Ignition	0.62 sec	0.03	451.92
Strap-on 1,2 Ignition	0.42 sec	0.03	451.92
First Stage Ignition	0 sec	0.03	451.92

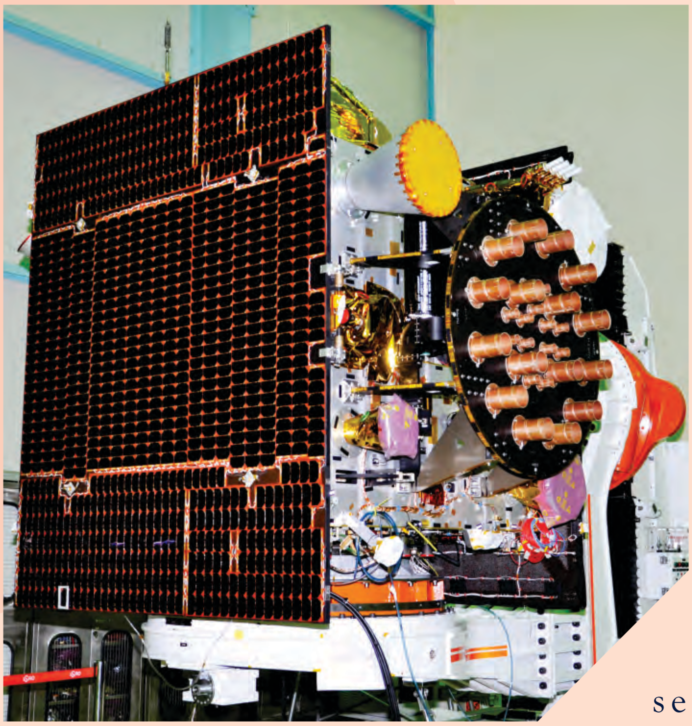
PSLV-C27 Typical Flight Profile

Placement of Nozzle End Segment of PSLV-C27 first stage over Launch Pedestal in progress



PSLV-C27 second stage during Vehicle Assembly

IRNSS-1D



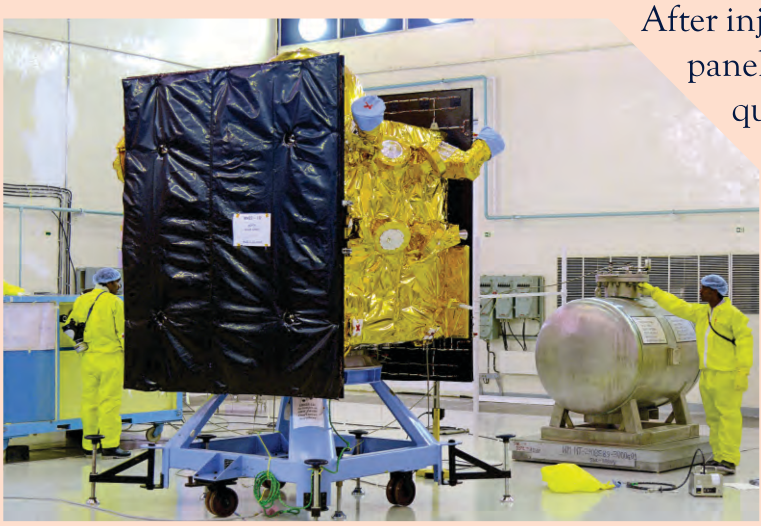
Closeup view of IRNSS-1D at Clean Room

IRNSS-1D is the fourth navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A, 1B and 1C were launched by PSLV-C22, PSLV-C24 and PSLV-C26 in July 2013, April 2014 and October 2014 respectively. IRNSS-1D has a lift-off mass of 1425 kg. The configuration of IRNSS-1D is similar to that of IRNSS-1A, 1B and 1C. The satellite has been realised in less than four months after the launch of its predecessor.

The two solar panels of IRNSS-1D consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1D maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.

IRNSS-1D undergoing solar panel deployment test

IRNSS-1D will be launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 20,650 km apogee (farthest point to Earth) with an inclination of 19.2 deg with respect to the equatorial plane.

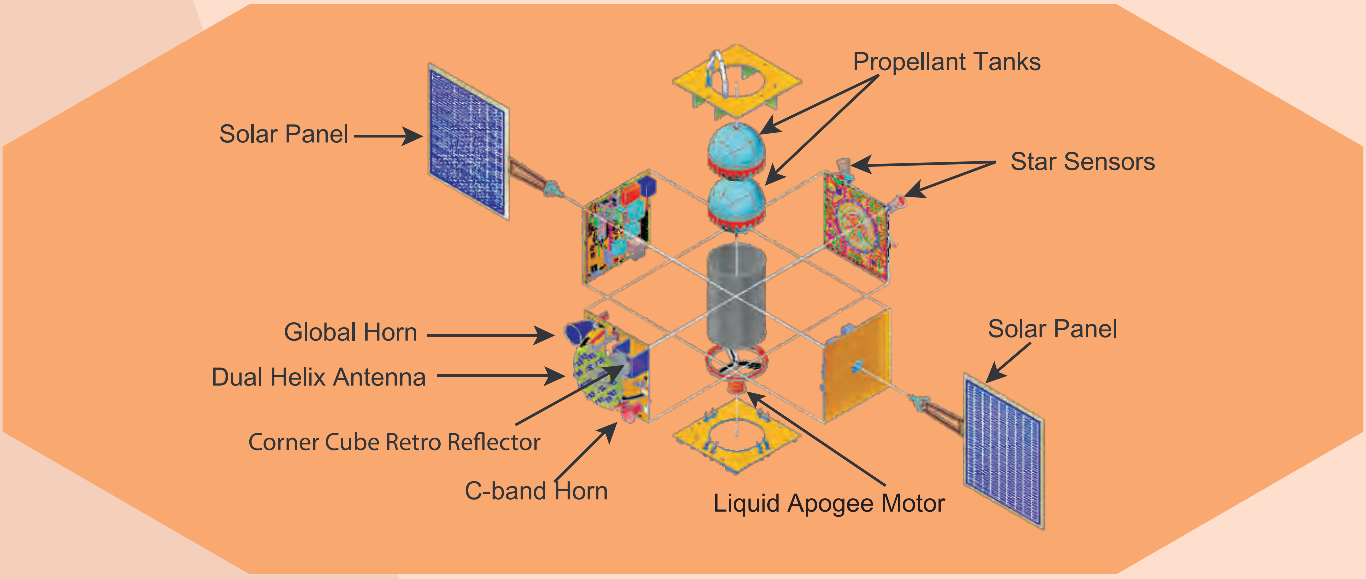


IRNSS-1D propellant filling operation in progress

After injection into this preliminary orbit, the two solar panels of IRNSS-1D are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of one manoeuvre at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the geosynchronous orbit at its designated location.

IRNSS-1D Salient features

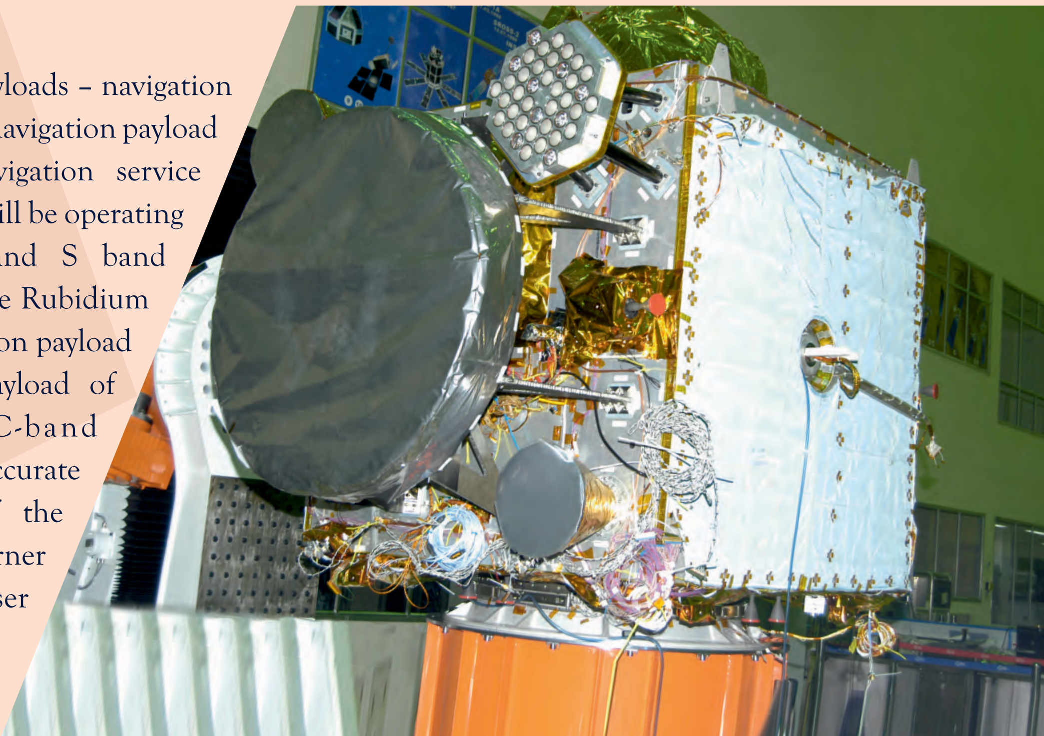
ORBIT	Geosynchronous, at 111.75 deg East longitude with 30.5 deg inclination
LIFT-OFF MASS	1425 kg
DRY MASS	603 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	10 years



IRNSS-1D Disassembled View

PAYLOADS:

IRNSS -1D carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1D will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1D consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1D also carries Corner Cube Retro Reflectors for laser ranging.



IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is the primary service area of IRNSS. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East.

IRNSS will provide two types of services, namely, Standard Positioning Service (SPS), which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS comprises of a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS-1A, 1B and 1C, the first three satellites of the IRNSS constellation, have already started functioning from their designated orbital slot after extensive on-orbit test and evaluation to confirm their satisfactory performance.

The IRNSS Signal-in-Space Interface Control Document (ICD) for SPS version 1.0 has been released in the official ISRO website http://irnss.isro.gov.in in October 2014. The information for a user to acquire, track and utilise the SPS navigation signals are provided in the ICD. The signal-in-space of three IRNSS satellites has been validated by various agencies within and outside the country.

With the operationalisation of IRNSS-1D, four active IRNSS satellites will be transmitting navigation signals. This meets the minimum number of satellites necessary for enabling a navigation receiver to compute its position. Thus, with IRNSS-1D functioning in orbit, proof-of-concept of an independent regional navigation satellite system over India can be established.

IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.

ISRO Navigation Centre at (INC) at Byalalu, the Nerve Centre of the IRNSS ground segment

Currently, IRNSS ground segment is operational on 24/7 basis with 12 Indian Range and Integrity Monitoring Stations (IRIMS), one IRNSS Network Timing Centre (IRNWT), one ISRO Navigation Centre (INC) and one Spacecraft Control Facility (SCF) with its data communication network. Along with the deployment of seven satellite constellation, the entire ground segment with three more IRIMS and one each of IRNWT, INC and SCF is planned to be established.

Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Vehicle tracking and fleet management
- Precise Timing
- Terrestrial navigation aid for hikers and travellers
- Disaster Management
- Integration with mobile phones
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers

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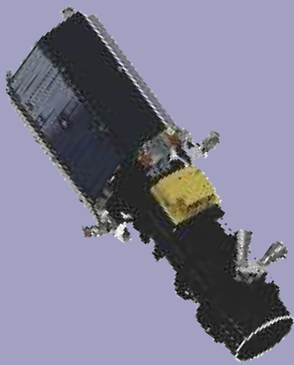
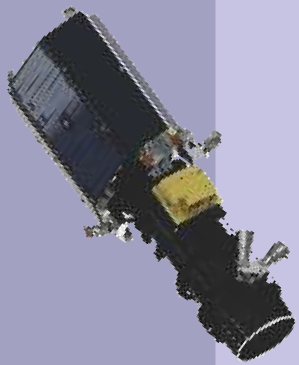
March 2015 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore

PSLV-C28
DMC3

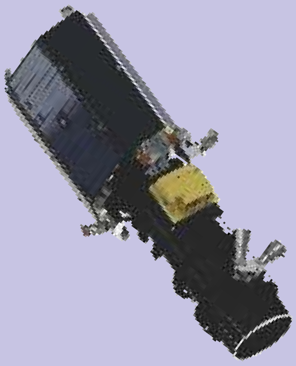
DMC3-1



DMC3-2

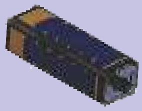


DMC3-3



CBNT-1

De-OrbitSail



PSLV-C28/DMC3 MISSION

PSLV-C28 at First Launch Pad

The Polar Satellite Launch Vehicle (PSLV), in its thirtieth flight (PSLV-C28), will launch three identical DMC3 optical earth observation satellites built by Surrey Satellite Technology Limited (SSTL), United Kingdom (UK). The three DMC3 satellites, each weighing 447 kg, will be launched into a 647 km Sun-Synchronous Orbit (SSO) using the high-end version of PSLV (PSLV-XL) from Satish Dhawan Space Centre, Sriharikota (SDSC-SHAR), the spaceport of India. PSLV-C28 will be the ninth flight of PSLV in 'XL' configuration.

The PSLV-C28, in addition to the three DMC3 satellites, will also carry two auxiliary satellites from UK, viz., CBNT-1, a technology demonstrator earth observation micro satellite built by SSTL, and De-OrbitSail, a technology demonstrator nano satellite built by Surrey Space Centre.

With the overall lift-off mass of the five satellites amounting to about 1440 kg, this mission becomes the heaviest commercial mission ever undertaken by Antrix/ISRO.

Accommodating the three DMC3 satellites each with a height of about 3 metre within the existing payload fairing of PSLV, was a challenge. To mount these satellites onto the launcher, a circular Launcher adaptor called as L-adaptor and a triangular deck called Multiple Satellite Adapter-Version 2 (MSA-V2), were newly designed and realised by ISRO for this specific purpose.

These international customer satellites are being launched as part of the agreement entered into between DMC International Imaging (DMCii), a wholly owned subsidiary of SSTL, UK and Antrix Corporation Limited (Antrix), the commercial arm of Indian Space Research Organisation (ISRO), a Government of India Company under Department of Space.

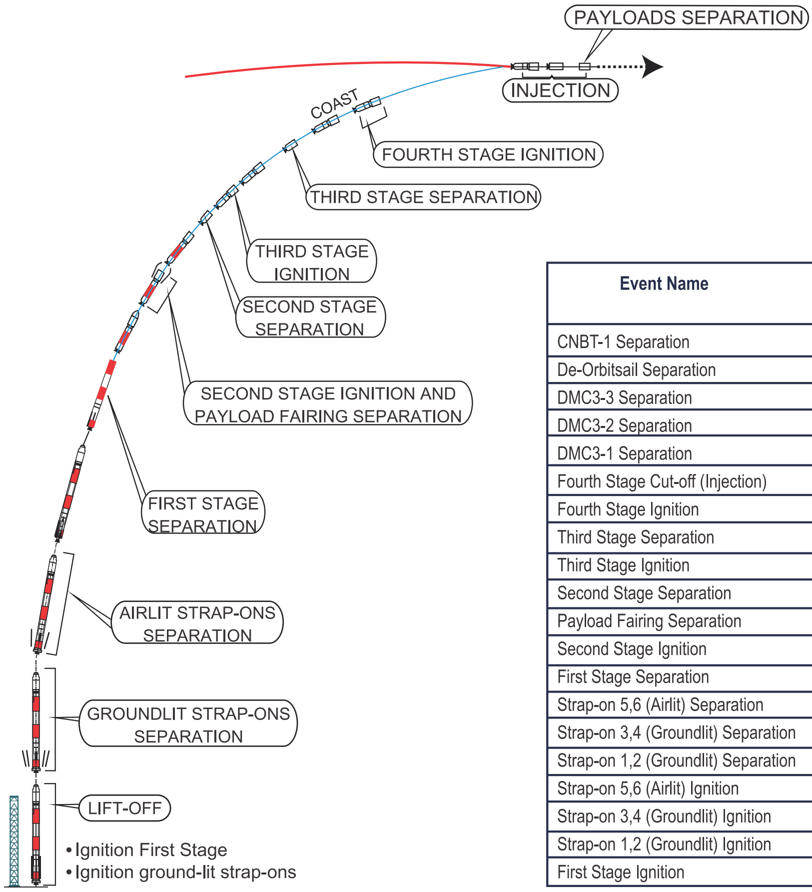
PSLV-C28 at a glance (Vehicle lift-off mass: 320 tonne Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Max Thrust (kN)	4819 (Core), 6 x 716 (Strap-on)	804	240	7.3 x 2
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene, UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate

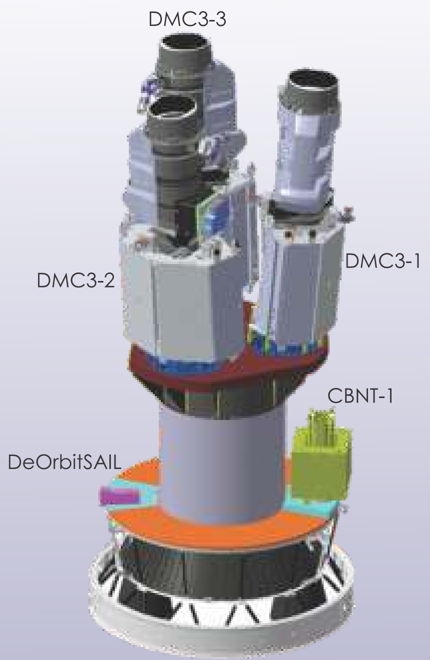
N_2O_4 : Nitrogen Tetroxide, MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C28/DMC3 MISSION

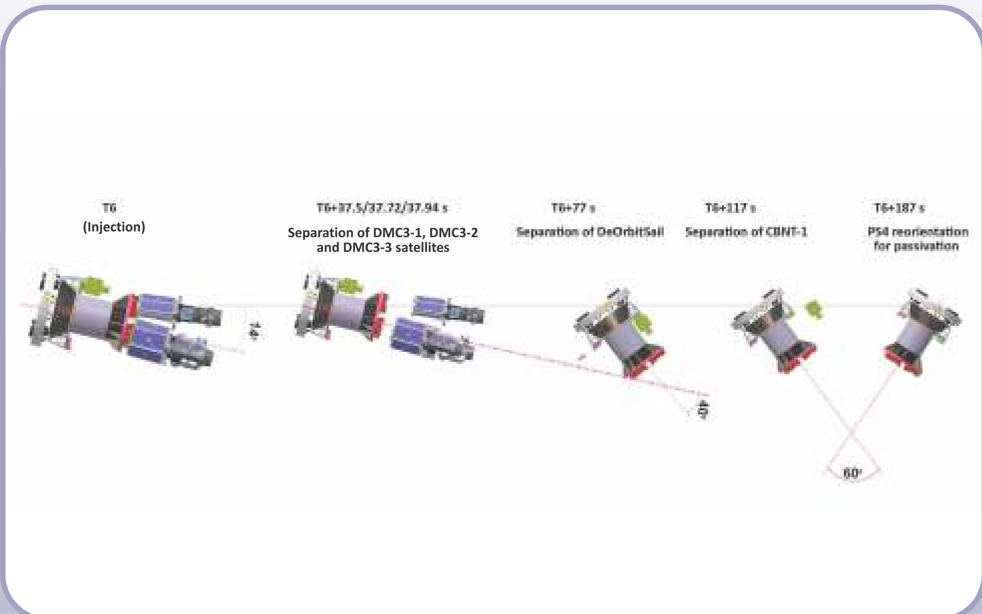


Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
CNBT-1 Separation	19 min 16.08 sec	654.75	7531.42
De-Orbitsail Separation	18 min 36.08 sec	653.09	7531.81
DMC3-3 Separation	17 min 57.02 sec	653.09	7532.16
DMC3-2 Separation	17 min 56.80 sec	653.09	7532.16
DMC3-1 Separation	17 min 56.58 sec	653.08	7532.16
Fourth Stage Cut-off (Injection)	17 min 19.08 sec	652.34	7527.46
Fourth Stage Ignition	8 min 47.20 sec	514.29	5948.51
Third Stage Separation	8 min 37.20 sec	506.29	5959.77
Third Stage Ignition	4 min 23.32 sec	233.25	4187.50
Second Stage Separation	4 min 22.12 sec	231.85	4190.50
Payload Fairing Separation	2 min 34.68 sec	118.51	2428.63
Second Stage Ignition	1 min 50.38 sec	69.06	2146.66
First Stage Separation	1 min 50.18 sec	68.82	2147.52
Strap-on 5,6 (Airlit) Separation	1 min 32.0 sec	47.47	1868.57
Strap-on 3,4 (Groundlit) Separation	1 min 10.1 sec	26.85	1308.81
Strap-on 1,2 (Groundlit) Separation	1 min 9.90 sec	26.69	1304.21
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.68	570.51
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0 sec	0.024	451.89

PSLV-C28 Typical Flight Profile



Location of payloads on the mounting adopters of PSLV-C28



Separation details of PSLV-C28 payloads

PSLV-C28/DMC3 MISSION

DMC3

The DMC3 constellation, comprising of three advanced mini-satellites DMC3-1, DMC3-2 and DMC3-3, is designed to address the need for simultaneous high spatial resolution and high temporal resolution optical Earth Observation. Launched into a single Low-Earth Orbit plane and phased with a separation of 120° between them, these satellites can image any target on the Earth's surface every day. Major application areas include surveying the resources on earth and its environment, managing urban infrastructure and monitoring of disasters.

CBNT-1 (left) and three DMC3 satellites (right) in clean room

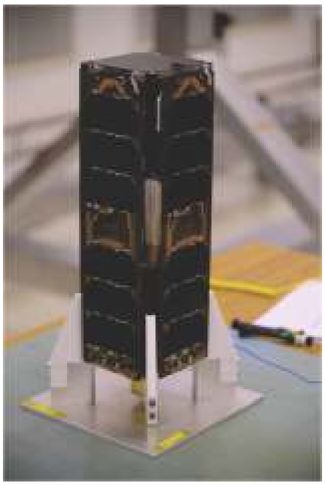
SURREY SATELLITE TECHNOLOGY LTD

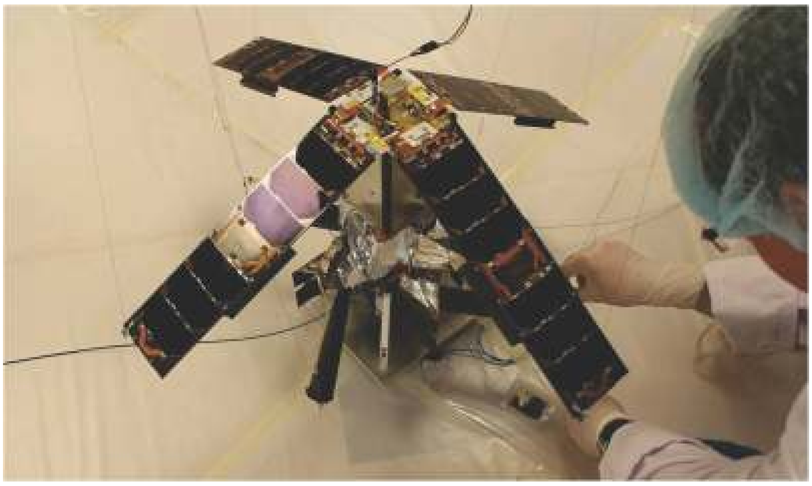
dmc International Imaging

Salient features of DMC3

Satellite mass	447 Kg
Orbit (Sun Synchronous Orbit)	647 km (Nominal)
Inclination	98.06 degree
Payload	High resolution Imager
Imaging Resolution	1m Panchromatic, 4m Multi-Spectral (Blue, Green, Red, NIR)
Swath width	23.35 km
Power	Lithium Ion 480 Whr, Solar panel – 230 W Peak BOL
Propulsion System	Xenon
Attitude control	3 axis stabilised, Wheels, Star Trackers, Magnetometers, Sun Sensors, Torque Rods
RF system	S- Band TTC, X- Band Payload Data
Mission life	7 years

CBNT-1 undergoing pre-launch tests





De-OrbitSail undergoing pre-launch tests

CBNT-1, weighing 91 kg, is an optical Earth Observation technology demonstration micro satellite built by SSTL. The 7 kg De-OrbitSail from Surrey Space Centre, is an experimental nano satellite for demonstration of large thin membrane sail and drag deorbiting using this sail.

Antrix Corporation Limited

Antrix Corporation Limited (Antrix), incorporated in 1992, is a wholly owned Government of India Company under the administrative control of Department of Space (DOS) and the commercial arm of Indian Space Research Organisation (ISRO). Antrix promotes and commercially exploits the products and services emanating from the Indian Space Programme. Antrix was awarded the 'MINIRATNA' status in the year 2008.

So far, Antrix has provided launch services on-board PSLV for 40 customer satellites from 19 countries. In addition to providing launch services for international customer satellites, Antrix provisions communication satellite transponders for broadcasting and telecommunication services, markets data from Indian Remote Sensing (IRS) satellites, builds and markets satellites and satellite subsystems and extends mission support services for satellite launches.

Satellites of other countries launched by PSLV

SL. NO.	NAME	COUNTRY	DATE OF LAUNCH	MASS (kg)	LAUNCH VEHICLE
1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
13	COMPASS-I	GERMANY	28-04-2008	3	PSLV-C9
14	SEEDS	JAPAN	28-04-2008	3	PSLV-C9
15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17	CUBESAT-1	GERMANY	23-09-2009	1	PSLV-C14
18	CUBESAT-2	GERMANY	23-09-2009	1	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21	RUBIN-9.1	GERMANY	23-09-2009	1	PSLV-C14
22	RUBIN-9.2	GERMANY	23-09-2009	1	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT-6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32	NLS8.1	AUSTRIA	25-02-2013	14	PSLV-C20
33	NLS8.2	AUSTRIA	25-02-2013	14	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UK	25-02-2013	6.5	PSLV-C20
36	SPOT-7	FRANCE	30-06-2014	714	PSLV-C23
37	AISAT	GERMANY	30-06-2014	14	PSLV-C23
38	NLS7.1(CAN-X4)	CANADA	30-06-2014	15	PSLV-C23
39	NLS7.2(CAN-X5)	CANADA	30-06-2014	15	PSLV-C23
40	VELOX-1	SINGAPORE	30-06-2014	7	PSLV-C23

June 2015 Design: info@smartworks.in | Printed by: M/s. Aditya Printers, Bangalore.

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PSLV-C29
TeLEOS-1
VELOX-CI
VELOX-II
Athenoxat-1
Galassia
Kent Ridge-1

PSLV-C29

PSLV-C29 at First Launch Pad

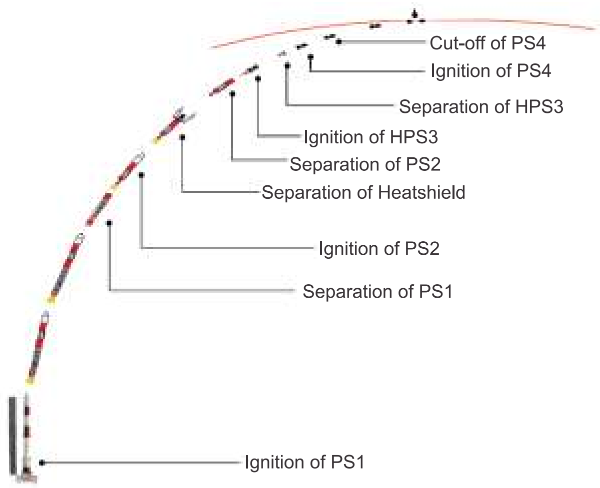
India's Polar Satellite Launch Vehicle, in its thirty second flight (PSLV-C29), will launch six satellites of Singapore into a 550 km circular orbit inclined at 15 degrees to the equator. Of these six satellites, TeLEOS-1 is the primary satellite weighing 400 kg whereas the other five are co-passenger satellites which include two microsatellites and three nanosatellites. PSLV-C29 will be launched from the First Launch Pad at Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. This is the eleventh flight of PSLV in 'core-alone' configuration (without the use of solid strap-on motors).

PSLV-C29 at a glance (Vehicle lift-off Mass: 227.6 tonne Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	PS1	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid UH25 + N_2O_4	Solid (HTPB based)	Liquid (MMH + MON-3)
Mass (tonne)	138.2	41.35	7.6	0.82
Stage Dia (m)	2.8	2.8	2.0	1.34
Stage Length (m)	20	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C29

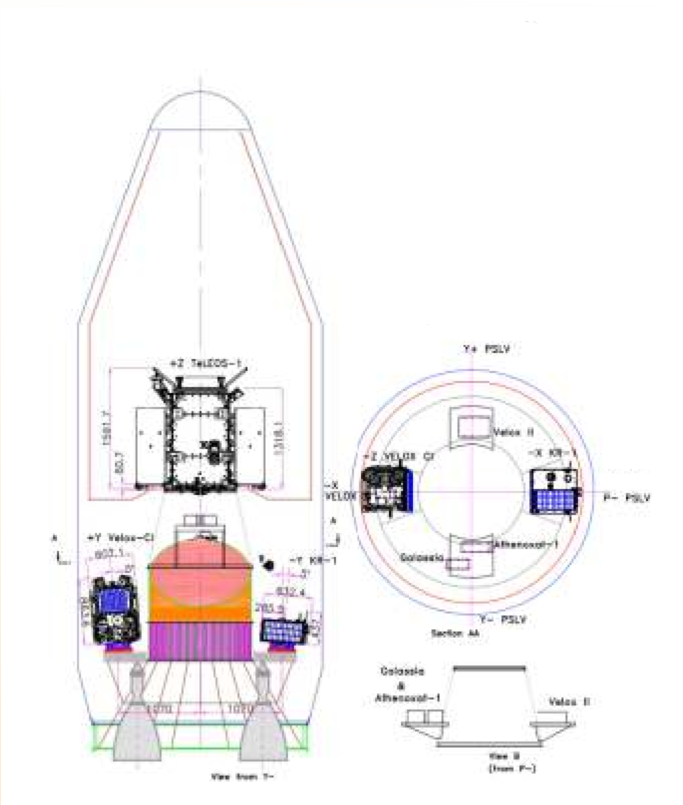


Mission Characteristics:

Orbit: 550 km circular
Inclination: 15 deg
Lift-off: 18:00 Hrs IST

Event Name	Time after lift-off (second)	Altitude (kilometre)	Velocity (metres/second)
Fourth Stage restart Cut-off	67 min 29.5 sec	524.0	7607.4
Fourth Stage restart	67 min 25.5 sec	523.9	7610.0
Athenoxat-1 Separation	21 min 2.0 sec	550.1	7585.6
Galassia Separation	20 min 7.0 sec	550.1	7585.4
VELOX-II Separation	19 min 12.0 sec	550.2	7585.3
VELOX-C1 Separation	18 min 42.4 sec	550.2	7585.3
Kent Ridge-1 Separation	18 min 42.0 sec	550.2	7585.3
TeLEOS-1 Separation	18 min 12.0 sec	550.2	7585.3
Fourth Stage Cut-off	17 min 25.0 sec	550.2	7581.5
Fourth Stage Ignition	15 min 7.5 sec	527.3	7348.9
Third Stage Separation	9 min 44.1 sec	379.9	7518.1
Third Stage Ignition	4 min 21.2 sec	200.6	4324.4
Second Stage Separation	4 min 20.0 sec	199.7	4326.3
Heat Shield Separation	2 min 53.3 sec	117.1	2251.8
Second Stage Ignition	1 min 53.3 sec	56.1	1648.7
First Stage Separation	1 min 53.08 sec	55.9	1649.8
First Stage Ignition	0.0	0.026	451.9

PSLV-C29 Typical Flight Profile



Satellites Mounting configuration

PSLV-C29 First Stage assembly

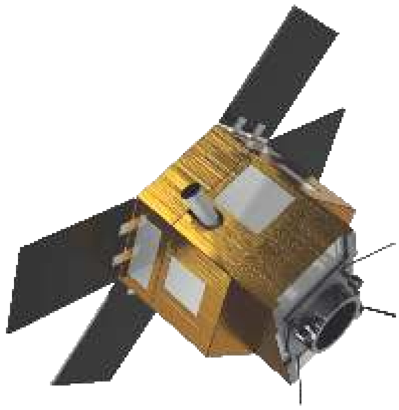
International Customer Satellites

Primary Satellite

TeLEOS-1

ST Electronics

TeLEOS-1 is the first Singapore commercial Earth observation satellite designed and developed by ST Electronics. This electro-optical satellite is to be launched into a low Earth orbit for remote sensing applications.



TeLEOS-1

TeLEOS-1 Features

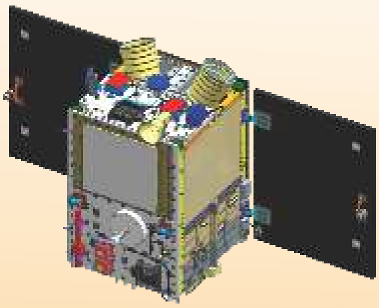
Satellite mass	400 kg
Orbit (Near Equatorial Orbit)	Period: 96 min, Inclination: 15°, Altitude: 550 km
Stowed Dimensions	1.9 m x 2.0 m x 1.6 m (H)
Imaging Resolution	1 m Panchromatic (at Nadir)
Swath Width	12 km (at Nadir)
Communications	S-Band Telemetry / X-Band Downlink
Mission Life	5 Years

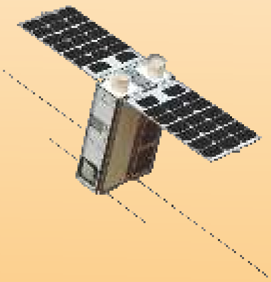
Co-passenger Satellites

VELOX-CI

Nanyang Technological University (NTU), Singapore

VELOX-CI is a 123 kg microsatellite for research in tropical environmental monitoring using radio occultation techniques. The satellite will be operated from the ground station located in NTU.





VELOX-II

Nanyang Technological University (NTU), Singapore

VELOX-II is a 13 kg 6U-Cubesat technology demonstrator with three payloads: Communications Payload, GPS Experimental Payload and Fault Tolerant Payload. This satellite will also be operated from the ground station in NTU.

International Customer Satellites

Athenoxat-1
Nanyang Technological University (NTU), Singapore

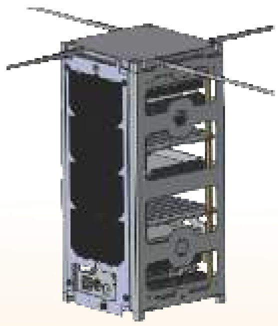
Athenoxat-1 has been designed, developed and built by Microspace Rapid Pvt Ltd in its Singapore laboratory. It is a technology demonstrator nanosatellite for Earth remote sensing based on a 3U-Cubesat form factor and launched as piggyback on a slot arranged by NTU.

Kent Ridge-1
National University of Singapore (NUS), Singapore

Kent Ridge-1 is an 78 kg microsatellite with two primary payloads: a Medium resolution VNIR Hyperspectral Camera (GSD 44m) and Short Wave Infrared (SWIR) Hyperspectral Camera (GSD 110m). Its secondary payload is a Real-time High Resolution Video (resolution 6m) camera. The modes of communication are UHF Telemetry link and X-band data downlink.

Galassia
National University of Singapore (NUS), Singapore

Galassia is a 3.4 kg 2U-Cubesat. It carries two payloads. One measures the total electron count in the ionosphere above Singapore and the other is a Small Photon-Entangling Quantum System to acquire quantum correlation data in space. The modes of communication are UHF uplink and VHF downlink.



Antrix Corporation Limited

Antrix Corporation Limited (Antrix), incorporated in 1992, is a wholly owned Government of India Company under the administrative control of Department of Space (DOS) and is the commercial arm of Indian Space Research Organisation (ISRO). Antrix promotes and commercially exploits the products and services emanating from the Indian Space Programme. Antrix was awarded the 'MINIRATNA' status in the year 2008.

So far, Antrix has provided launch services on-board PSLV for 51 customer satellites from 20 countries. In addition to providing launch services for international customer satellites, Antrix provisions communication satellite transponders for broadcasting and telecommunication services, markets data from Indian Remote Sensing (IRS) satellites, builds and markets satellites and satellite subsystems and extends mission support services for satellite launches.

Satellites of other countries launched by PSLV

SL. NO.	NAME	COUNTRY	DATE OF LAUNCH	MASS (kg)	LAUNCH VEHICLE
1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
13	COMPASS-I	GERMANY	28-04-2008	3	PSLV-C9
14	SEEDS	JAPAN	28-04-2008	3	PSLV-C9
15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17	CUBESAT-1	GERMANY	23-09-2009	1	PSLV-C14
18	CUBESAT-2	GERMANY	23-09-2009	1	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21	RUBIN-9.1	GERMANY	23-09-2009	1	PSLV-C14
22	RUBIN-9.2	GERMANY	23-09-2009	1	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT-6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32	NLS8.1	AUSTRIA	25-02-2013	14	PSLV-C20
33	NLS8.2	AUSTRIA	25-02-2013	14	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UNITED KINGDOM	25-02-2013	6.5	PSLV-C20
36	SPOT-7	FRANCE	30-06-2014	714	PSLV-C23
37	AISAT	GERMANY	30-06-2014	14	PSLV-C23
38	NLS7.1(CAN-X4)	CANADA	30-06-2014	15	PSLV-C23
39	NLS7.2(CAN-X5)	CANADA	30-06-2014	15	PSLV-C23
40	VELOX-1	SINGAPORE	30-06-2014	7	PSLV-C23
41	DMC3-1	UNITED KINGDOM	10-07-2015	447	PSLV-C28
42	DMC3-2	UNITED KINGDOM	10-07-2015	447	PSLV-C28
43	DMC3-3	UNITED KINGDOM	10-07-2015	447	PSLV-C28
44	CBNT-1	UNITED KINGDOM	10-07-2015	91	PSLV-C28
45	De-OrbitSail	UNITED KINGDOM	10-07-2015	7	PSLV-C28
46	LAPAN-A2	INDONESIA	28-09-2015	76	PSLV-C30
47	NLS-14 (Ev9)	CANADA	28-09-2015	14	PSLV-C30
48	LEMUR	USA	28-09-2015	7	PSLV-C30
49	LEMUR	USA	28-09-2015	7	PSLV-C30
50	LEMUR	USA	28-09-2015	7	PSLV-C30
51	LEMUR	USA	28-09-2015	7	PSLV-C30

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PSLV
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INDIA
PSLV-C30
ASTROSAT

ASTROSAT

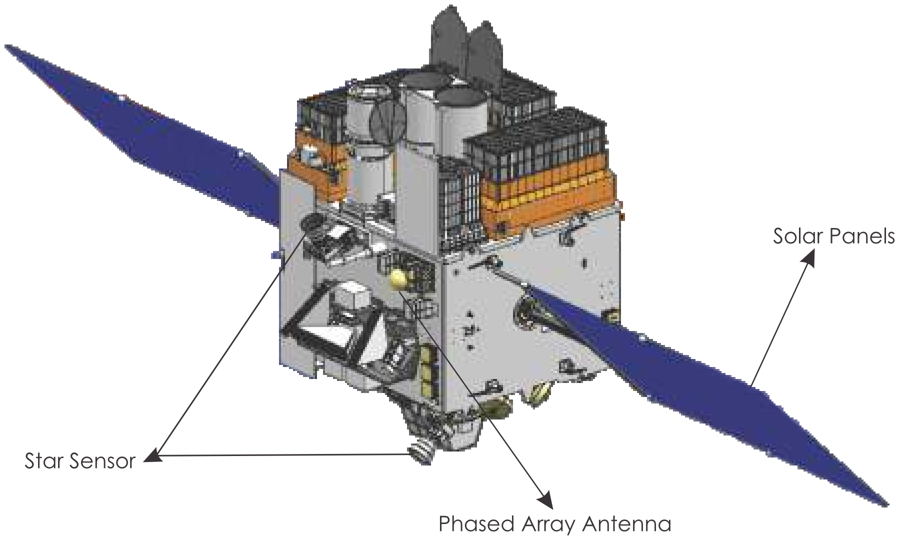
Integration of ASTROSAT in a clean room at ISRO Satellite Centre

ASTROSAT is India's first dedicated multi wavelength space observatory. This scientific satellite mission endeavours for a more detailed understanding of our universe. One of the unique features of ASTROSAT mission is that it enables the simultaneous multi-wavelength observations of various astronomical objects with a single satellite.

ASTROSAT will observe universe in the optical, Ultraviolet, low and high energy X-ray regions of the electromagnetic spectrum, whereas most other scientific satellites are capable of observing a narrow range of wavelength band. Multi-wavelength observations of ASTROSAT can be further extended with co-ordinated observations using other spacecraft and ground based observations. All major astronomy Institutions and some Universities in India will participate in these observations.

ASTROSAT has a lift-off mass of 1513 kg. It will be launched into a 650 km orbit inclined at an angle of 6 deg to the equator by India's Polar Satellite Launch Vehicle (PSLV) during its thirty first mission (PSLV-C30).

ASTROSAT Configuration



The cuboid shaped ASTROSAT has two solar arrays consisting of Triple Junction solar cells that generate 2100 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical payload elements. The Attitude and Orbit Control System (AOCS) of Astrosat very accurately maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters.

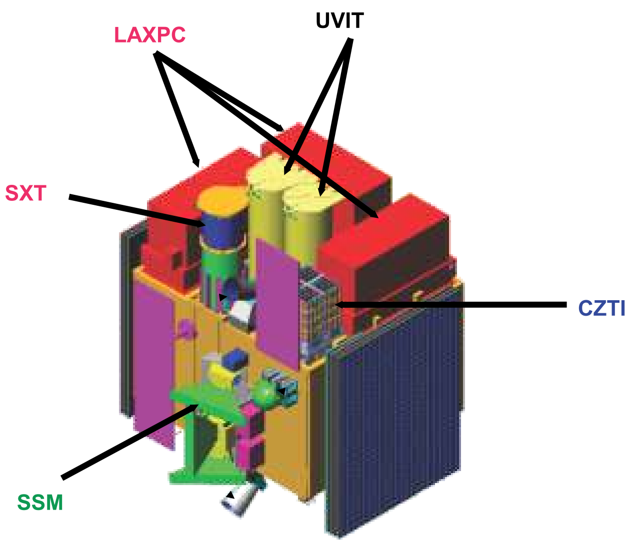
After injection into Orbit, the two solar panels of ASTROSAT are automatically deployed in quick succession and the spacecraft control centre at Mission Operations Complex (MOX) of ISRO Telemetry, Tracking and Command Network (ISTRAC) at Bangalore manages the satellite during its mission life.

The science data gathered by five payloads of ASTROSAT are telemetered to the ground station at MOX. The data is then processed, archieved and distributed by Indian Space Science Data Centre (ISSDC) located at Byalalu, near Bangalore.

ASTROSAT Salient features

ORBIT	650 km Equatorial with 6 deg inclination
LIFT-OFF MASS	1513 kg
DRY MASS	1470 kg
PHYSICAL DIMENSIONS	1.96 metre x 1.75 metre x 1.30 metre
POWER	Two solar arrays generating 2100 W, two Lithium-ion batteries of 36 Ampere-Hour capacity each
PROPULSION	Eight 11 Newton Hydrazine based Monopropellant Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 11 Newton thrusters as actuators
MISSION LIFE	5 years

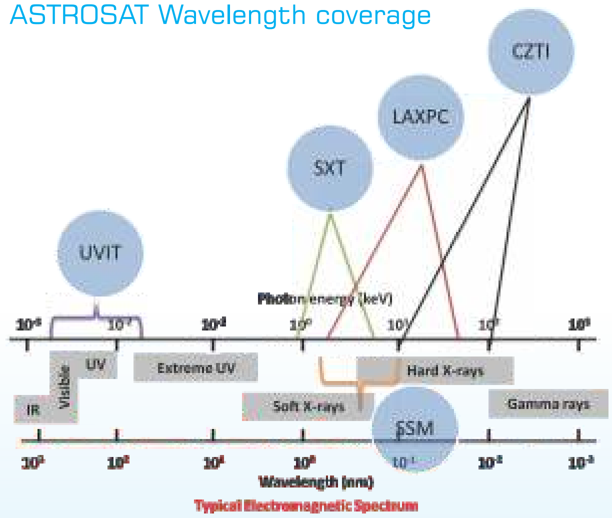
ASTROSAT PAYLOADS



Astrosat Payload Locations

Though most of ISRO satellite missions are applications oriented, the remaining ones are scientific in nature. The first Indian satellite Aryabhata was a scientific satellite. This was followed by such scientific satellite missions like SROSS and Youthsat. Besides, IRS-P3 and GSAT-2 carried onboard piggyback scientific experiments in astronomy. This apart, Chandrayaan-1 and Mars Orbiter Mission, successfully explored the Moon and Mars respectively. ASTROSAT is the next major space science mission of ISRO.

ASTROSAT Wavelength coverage



The scientific objectives of ASTROSAT mission are:

- To understand high energy processes in binary star systems containing neutron stars and black holes
- Estimate magnetic fields of neutron stars
- Study star birth regions and high energy processes in star systems lying beyond our galaxy
- Detect new briefly bright X-ray sources in the sky
- Perform a limited deep field survey of the Universe in the Ultraviolet region

ASTROSAT's five payloads are chosen to facilitate a deeper insight into the various astrophysical processes occurring in the various types of astronomical objects constituting our universe. These payloads rely on the visible, Ultraviolet and X-rays coming from distant celestial sources.

Of the five scientific payloads of ASTROSAT, the **Ultraviolet Imaging Telescope (UVIT)** is jointly developed by Indian Institute of Astrophysics (IIA) at Bangalore and Inter University Centre for Astronomy and Astrophysics (IUCAA) at Pune in collaboration with ISRO and the Canadian Space Agency. This instrument is capable of observing the sky in the visible, near Ultraviolet and far Ultraviolet regions of the electromagnetic spectrum. The two telescopes of the UVIT payload are designed to achieve an excellent image resolution and they also have a large field of view.

Large Area X-ray Proportional Counter (LAXPC), the second payload of ASTROSAT, is designed to study the variations in the emission of X-rays from sources like X-ray binaries, Active Galactic Nuclei and other cosmic sources. It can make measurements of spectral characteristics of different classes of X-ray sources over a wide spectral range of 3-80 kilo electron Volts (keV). LAXPC has nearly five times more effective area for collecting X-ray photons with energy beyond 25 keV compared to other similar scientific satellite mission. Tata Institute of Fundamental Research (TIFR) of Mumbai and Raman Research Institute (RRI) of Bangalore have developed this payload.

ASTROSAT PAYLOADS

Soft X-ray Telescope (SXT) payload of ASTROSAT developed by TIFR in collaboration with the University of Leicester, UK and ISRO, is designed for studying how the X-ray spectrum of 0.3-8 keV range coming from distant celestial bodies varies with time. Such studies help in understanding the characteristics of the bodies which emitted this particular types of X-rays. This payload has a 2 metre focal length telescope with thin conical foil Gold coated Aluminium foil mirrors for reflecting the X-rays that are incident at a very shallow angle. The focal plane camera of this instrument has a cooled Charge Coupled Device.

Cadmium Zinc Telluride Imager (CZTI), yet another ASTROSAT payload functioning in the X-ray region, extends the capability of the satellite to sense X-rays of high energy in 10-100 keV range. Thus, apart from supplementing the spectral studies afforded by the LAXPC, CZTI payload may also be able to detect gamma ray bursts and study their characteristics. CZTI payload was developed by TIFR and IUCAA in collaboration with ISRO.

The fifth payload of ASTROSAT is the **Scanning Sky Monitor (SSM)**, developed by ISRO Satellite Centre at Bangalore and IUCAA. This instrument is intended to scan the sky for long term monitoring of bright X-ray sources in binary stars, and for the detection and location of sources that become bright in X-rays for a short duration of time. Such transient sources of X-rays will then be studied in detail by other instruments on ASTROSAT.

ASTROSAT was realised with the participation of all major astronomy institutions and some of the Universities in India. It is the first satellite mission to be operated in India as a space observatory. The challenges faced during the development of ASTROSAT include the realisation of a high resolution UVIT including its special coating materials, optical elements, ensuring stringent contamination control for that payload, development of indigenous thin foil and gold coated Aluminium X-ray optics in SXT, high pressure counters of LAXPC, critical thermal control design for all the payloads and special software essential for data flow and satellite operations.

ASTROSAT PAYLOADS

Payload	Energy range	Description	Angular resolution	sensitivity
SXT	0.3 – 8 keV	X-ray foil mirror + CCD FOV=42'	3 – 4 arcmin	~0.01milliCrab (10,000 sec)
LAXPC	3 – 80 keV	Large proportional counters (3)	~5arcmin (scan mode)	0.1 milliCrab (1000 sec)
CZT-imager	10 – 100 keV	CZT array (hard X-ray imager)	8 arcmin	0.5 milliCrab (10,000 sec)
SSM	2.5 – 10 keV	Sky monitors (3) on a boom	5 – 10 arcmin	30 milliCrab (600 sec)
UVIT	1300 – 6500 Ang	Twin RC telescopes – 40 cm each (NUV,VIS, FUV)	1.8 arc sec	20 magnitude (200 sec)

PSLV-C30

PSLV-C30 at First Launch Pad

India's Polar Satellite Launch Vehicle, in its thirty first flight (PSLV-C30), is scheduled to launch 1513 kg ASTROSAT into a 650 km orbit of 6 deg inclination to the equator. Along with ASTROSAT, six satellites from international customers viz., 76 kg LAPAN-A2 of Indonesia, 14 kg NLS-14 (Ev9) of Canada and four identical LEMUR satellites of USA together weighing about 28 kg – will be launched in this PSLV flight. PSLV-C30 will be launched from First Launch Pad of Satish Dhawan Space Centre SHAR, Sriharikota. PSLV-C30 is the tenth flight of PSLV in its 'XL' Configuration. The earlier nine flights of PSLV-XL were PSLV-C11/Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/RISAT-1, PSLV-C22/IRNSS-1A, PSLV-C25/Mars Orbiter Spacecraft, PSLV-C24/IRNSS-1B and PSLV-C26/IRNSS-1C, PSLV-C27/IRNSS-1D, PSLV-C28/DMC3 missions. The total payload weight of PSLV-C30 is 1631 kg.

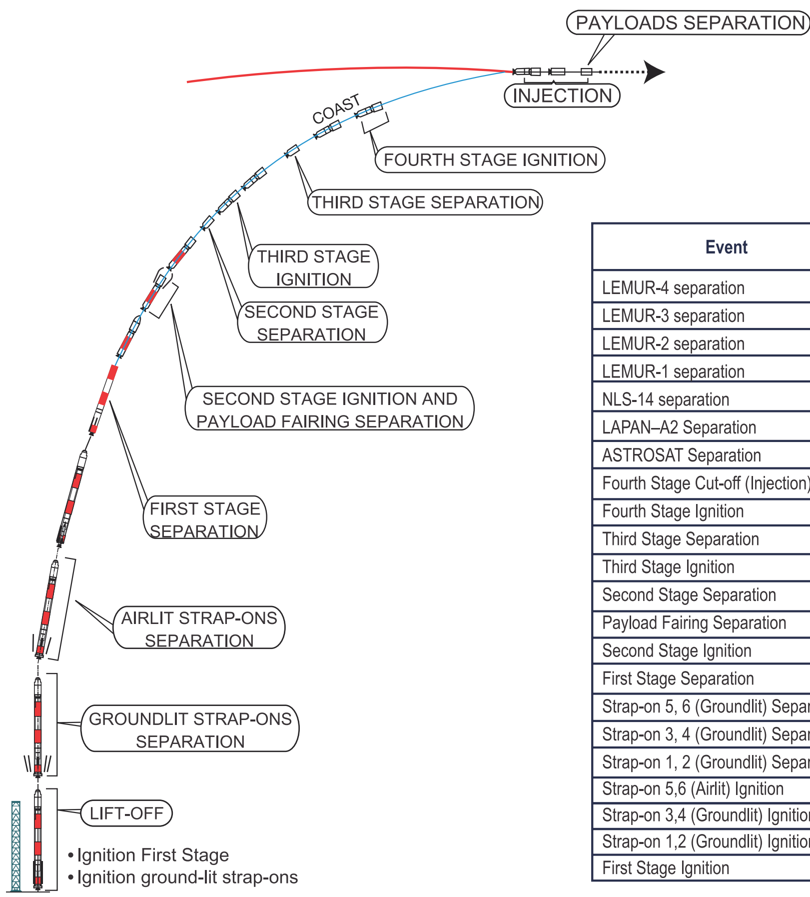
PSLV-C30 at a glance (Vehicle lift-off mass: 320.2 tonne Height: 44.4 m)

	Stage-1	*Stage-2*	*Stage-3*	*Stage-4*
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	41.35	7.6	1.6
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.34
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene, UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate

N_2O_4 : Nitrogen Tetroxide, MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C30



Event	Time (S)	Local Attitude (km)	Internal Velocity (m/s)
LEMUR-4 separation	25min 32.92 sec	649.97	7531.20
LEMUR-3 separation	25min 12.92 sec	650.00	7531.15
LEMUR-2 separation	24min 02.92 sec	650.06	7531.08
LEMUR-1 separation	24min 02.92 sec	650.11	7531.03
NLS-14 separation	23min 27.92 sec	650.14	7530.98
LAPAN–A2 Separation	23min 02.92 sec	650.16	7530.95
ASTROSAT Separation	22min 32.92 sec	650.17	7530.94
Fourth Stage Cut-off (Injection)	21min 55.92 sec	650.17	7528.89
Fourth Stage Ignition	16min 57 sec	583.67	7258.15
Third Stage Separation	9min 47.64 sec	335.54	7544.63
Third Stage Ignition	4min 24.18 sec	157.90	5289.62
Second Stage Separation	4min 22.99 sec	157.76	5289.89
Payload Fairing Separation	2min 49.2 sec	113.97	2982.91
Second Stage Ignition	1min 52.2 sec	64.36	2337.51
First Stage Separation	1min 52 sec	64.16	2338.15
Strap-on 5, 6 (Groundlit) Separation	1min 32.0 sec	43.73	2028.58
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	25.40	1421.08
Strap-on 1, 2 (Groundlit) Separation	1min 9.90 sec	25.25	1416.29
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.75	604.69
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0.00	0.024	451.89

PSLV-C30 Typical Flight Profile

International Customer Satellites of PSLV-C30

LAPAN-A2 is a Microsatellite from National Institute of Aeronautics and Space-LAPAN, Indonesia. LAPAN-A2 is meant for providing maritime surveillance using Automatic Identification System (AIS), supporting Indonesian radio amateur communities for disaster mitigation and carrying out Earth surveillance using video and digital camera.

NLS-14 (Ev9), a Nanosatellite from Space Flight Laboratory, University of Toronto Institute for Advanced Studies (SFL, UTIAS), Canada. It is a maritime monitoring Nanosatellite using the next generation Automatic Identification System (AIS).

Four LEMUR nano satellites from Spire Global, Inc. (San Francisco, CA), USA, are non-visual remote sensing satellites, focusing primarily on global maritime intelligence through vessel tracking via the Automatic Identification System (AIS), and high fidelity weather forecasting using GPS Radio Occultation technology.

Satellites of other countries launched by PSLV

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1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
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15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17	CUBESAT-1	GERMANY	23-09-2009	1	PSLV-C14
18	CUBESAT-2	GERMANY	23-09-2009	1	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21	RUBIN-9.1	GERMANY	23-09-2009	1	PSLV-C14
22	RUBIN-9.2	GERMANY	23-09-2009	1	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT-6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32	NLS8.1	AUSTRIA	25-02-2013	14	PSLV-C20
33	NLS8.2	AUSTRIA	25-02-2013	14	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UNITED KINGDOM	25-02-2013	6.5	PSLV-C20
36	SPOT-7	FRANCE	30-06-2014	714	PSLV-C23
37	AISAT	GERMANY	30-06-2014	14	PSLV-C23
38	NLS7.1(CAN-X4)	CANADA	30-06-2014	15	PSLV-C23
39	NLS7.2(CAN-X5)	CANADA	30-06-2014	15	PSLV-C23
40	VELOX-1	SINGAPORE	30-06-2014	7	PSLV-C23
41	DMC3-1	UNITED KINGDOM	10-07-2015	447	PSLV-C28
42	DMC3-2	UNITED KINGDOM	10-07-2015	447	PSLV-C28
43	DMC3-3	UNITED KINGDOM	10-07-2015	447	PSLV-C28
44	CBNT-1	UNITED KINGDOM	10-07-2015	91	PSLV-C28
45	De-OrbitSail	UNITED KINGDOM	10-07-2015	7	PSLV-C28

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New BEL Road, Bangalore - 560 231, India.
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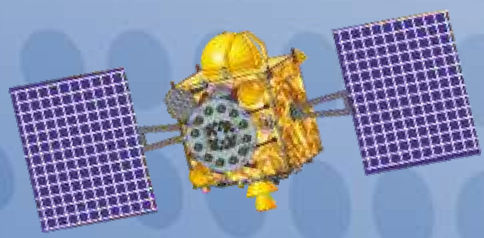
PSLV-C31
IRNSS-1E



PSLV-C31

PSLV-C31 at Second Launch Pad

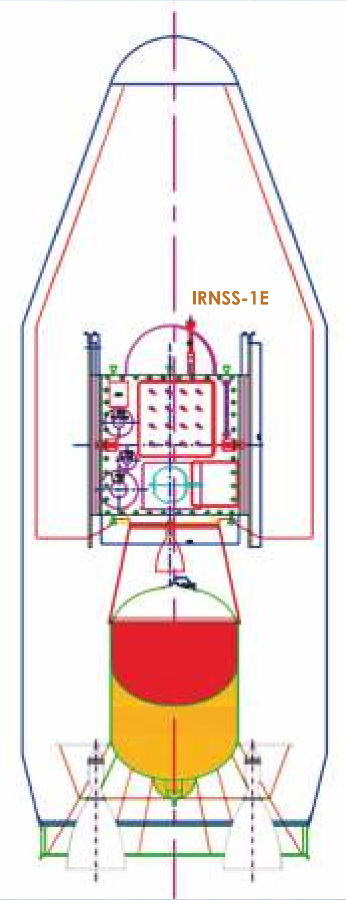
Polar Satellite Launch Vehicle, in its thirty third flight (PSLV-C31), will launch IRNSS-1E, the fifth satellite of the Indian Regional Navigation Satellite System (IRNSS). The launch will take place from the Second Launch Pad (SLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. As in the previous four launches of IRNSS satellites, PSLV-C31 will use 'XL' version of PSLV. This is the eleventh time 'XL' configuration is being flown, earlier ten being PSLV-C11/Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/RISAT-1, PSLV-C22/IRNSS-1A, PSLV-C25/Mars Orbiter Spacecraft, PSLV-C24/IRNSS-1B, PSLV-C26/IRNSS-1C, PSLV-C27/IRNSS-1D, PSLV-C28/DMC-3 and PSLV-C30/ASTROSAT missions.

PSLV-C31 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

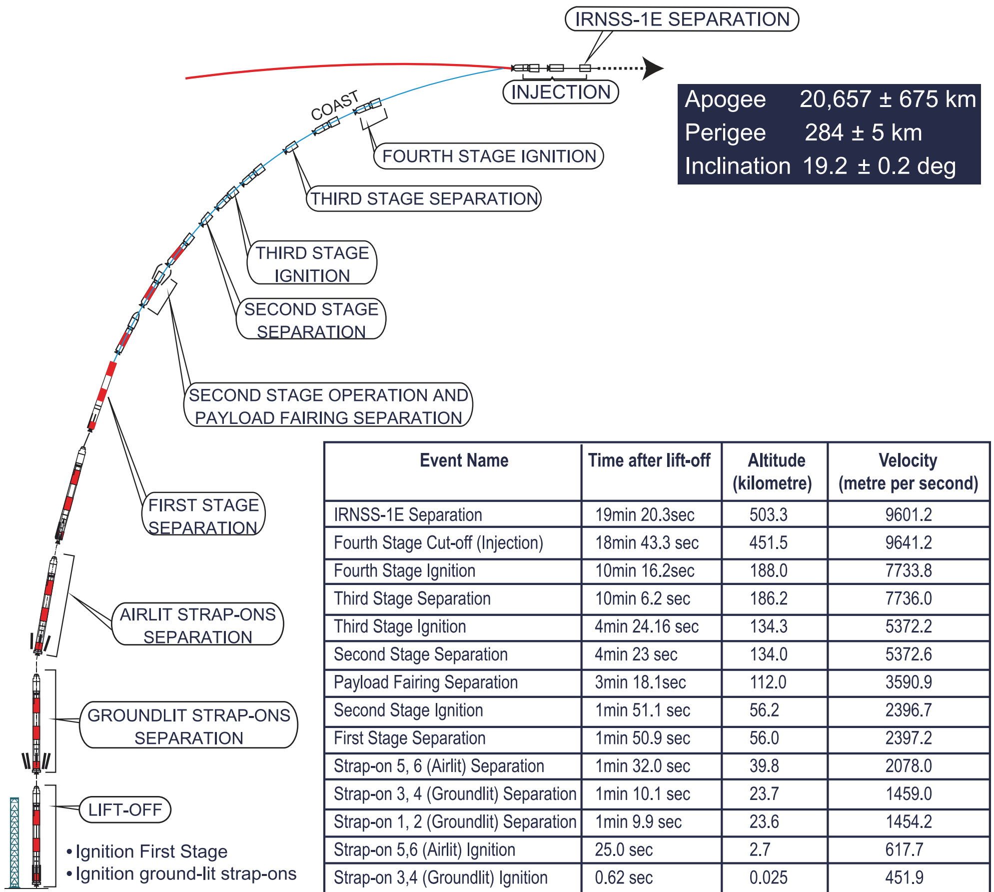
	Stage-1	*Stage-2*	*Stage-3*	*Stage-4*
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C31



IRNSS-1E in PSLV-C31 Envelope



Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1E Separation	19min 20.3sec	503.3	9601.2
Fourth Stage Cut-off (Injection)	18min 43.3 sec	451.5	9641.2
Fourth Stage Ignition	10min 16.2sec	188.0	7733.8
Third Stage Separation	10min 6.2 sec	186.2	7736.0
Third Stage Ignition	4min 24.16 sec	134.3	5372.2
Second Stage Separation	4min 23 sec	134.0	5372.6
Payload Fairing Separation	3min 18.1sec	112.0	3590.9
Second Stage Ignition	1min 51.1 sec	56.2	2396.7
First Stage Separation	1min 50.9 sec	56.0	2397.2
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	39.8	2078.0
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	23.7	1459.0
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	23.6	1454.2
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.7	617.7
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.025	451.9
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.025	451.9
First Stage Ignition	0.00	0.025	451.9

PSLV-C31 Typical Flight Profile

Integration of an 'XL' strap-on motor
with the core stage of PSLV-C31 in progress

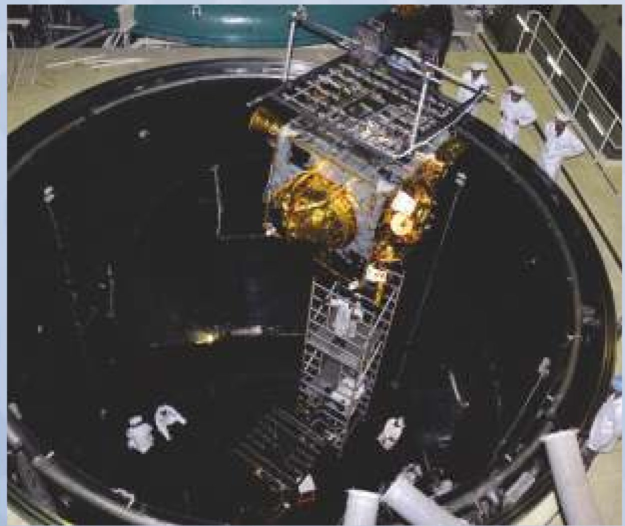
PSLV-C31 second stage
during Vehicle Assembly

IRNSS-1E

IRNSS-1E integeration in progress at Clean Room

IRNSS-1E is the fifth navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A, 1B, 1C and 1D were launched by PSLV-C22, PSLV-C24, PSLV-C26 and PSLV-C27 in July 2013, April 2014, October 2014 and March 2015 respectively. IRNSS-1E has a lift-off mass of 1425 kg. The configuration of IRNSS-1E is similar to that of IRNSS-1A, 1B, 1C and 1D.

The two solar arrays of IRNSS-1E consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1E maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.



IRNSS-1E being loaded into the Large Space Simulation Chamber for thermal vacuum test

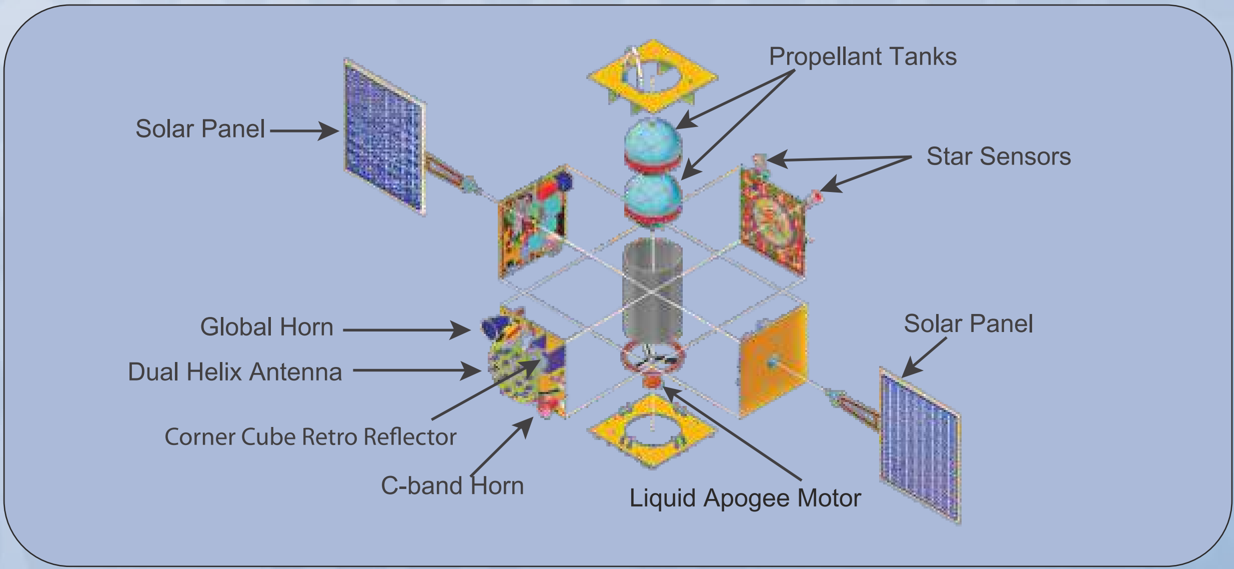
IRNSS-1E will be launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 20,657 km apogee (farthest point to Earth) with an inclination of 19.2 deg with respect to the equatorial plane.

After injection into this preliminary orbit, the two solar panels of IRNSS-1E are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of one manoeuvre at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the geosynchronous orbit at 111.75 deg E location with an initial inclination of 28.1 deg with respect to the equator.

IRNSS-1E propellant filling operation in progress

IRNSS-1E Salient features

ORBIT	Geosynchronous, at 111.75 deg East longitude with 28.1 deg inclination
LIFT-OFF MASS	1425 kg
DRY MASS	598 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	12 years



IRNSS-1E Disassembled View

PAYLOADS:

IRNSS -1E carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1E will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1E consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1E also carries Corner Cube Retro Reflectors for laser ranging.

IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is the primary service area of IRNSS. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East.

IRNSS will provide two types of services, namely, Standard Positioning Service (SPS), which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS comprises of a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS-1A, 1B,1C and 1D the first four satellites of the IRNSS constellation, have already started functioning from their designated orbital slots after extensive on-orbit test and evaluation to confirm their satisfactory performance.

The IRNSS Signal-in-Space Interface Control Document (ICD) for SPS version 1.0 was released in the official ISRO website http://irnss.isro.gov.in in October 2014. The information for a user to acquire, track and utilise the SPS navigation signals are provided in the ICD. The signal-in-space of four IRNSS satellites has been validated by various agencies within and outside the country.

The current achieved position accuracy is 20 metres over 18 hours of the day with four satellites. With the launch of IRNSS-1E and the subsequent 1F and 1G in February and March 2016, the IRNSS constellation will be completed for the total operational use.

IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.

ISRO Navigation Centre at (INC) at Byalalu, the Nerve Centre of the IRNSS ground segment

Currently, IRNSS ground segment is operational on 24/7 basis with 13 Indian Range and Integrity Monitoring Stations (IRIMS), one IRNSS Network Timing Centre (IRNWT), one ISRO Navigation Centre (INC) and one Spacecraft Control Facility (SCF) with its data communication network. Along with the deployment of seven satellite constellation, the entire ground segment with two more IRIMS and one each of IRNWT, INC and SCF is planned to be established.

Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Vehicle tracking and fleet management
- Precise Timing
- Terrestrial navigation aid for hikers and travellers
- Disaster Management
- Integration with mobile phones
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers

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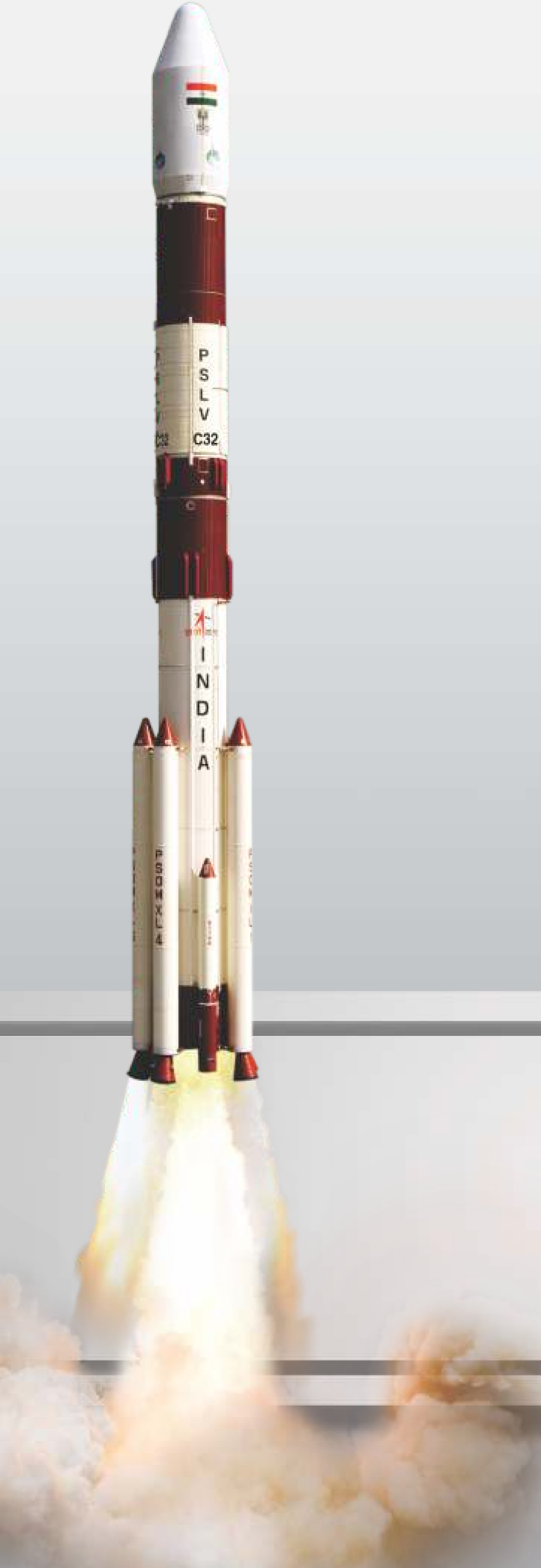
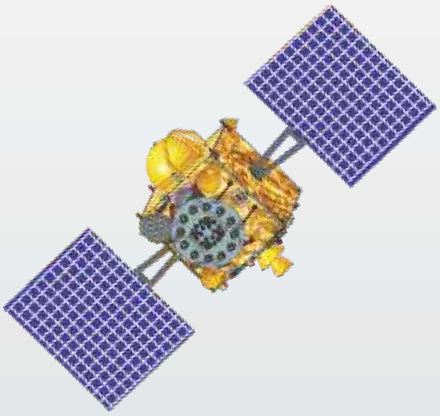
January 2016 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore





PSLV-C32
IRNSS-1F

PSLV-C32

PSLV-C32 at the Second Launch Pad

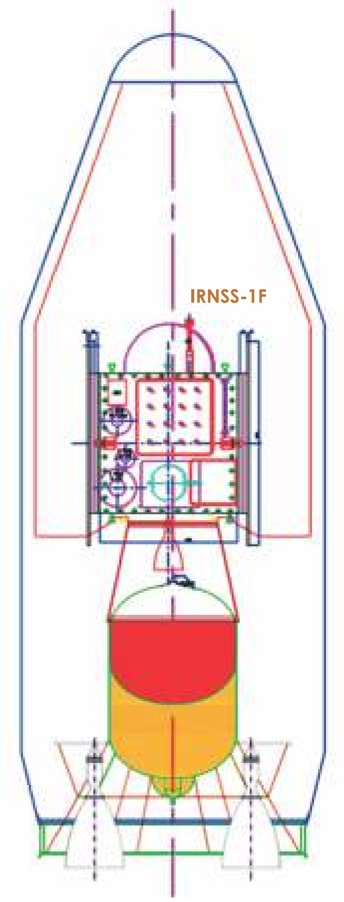
Polar Satellite Launch Vehicle, in its thirty fourth flight (PSLV-C32), will launch IRNSS-1F, the sixth satellite of the Indian Regional Navigation Satellite System (IRNSS). The launch will take place from the Second Launch Pad (SLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. As in the previous five launches of IRNSS satellites, PSLV-C32 will use 'XL' version of PSLV. This is the twelth time 'XL' configuration is being flown, earlier eleven being PSLV-C11/Chandrayaan-1, PSLV-C17/GSAT-12, PSLV-C19/RISAT-1, PSLV-C22/IRNSS-1A, PSLV-C25/Mars Orbiter Spacecraft, PSLV-C24/IRNSS-1B, PSLV-C26/IRNSS-1C, PSLV-C27/IRNSS-1D, PSLV-C28/DMC-3, PSLV-C30/ASTROSAT and PSLV-C31/IRNSS-1E missions.

PSLV-C32 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

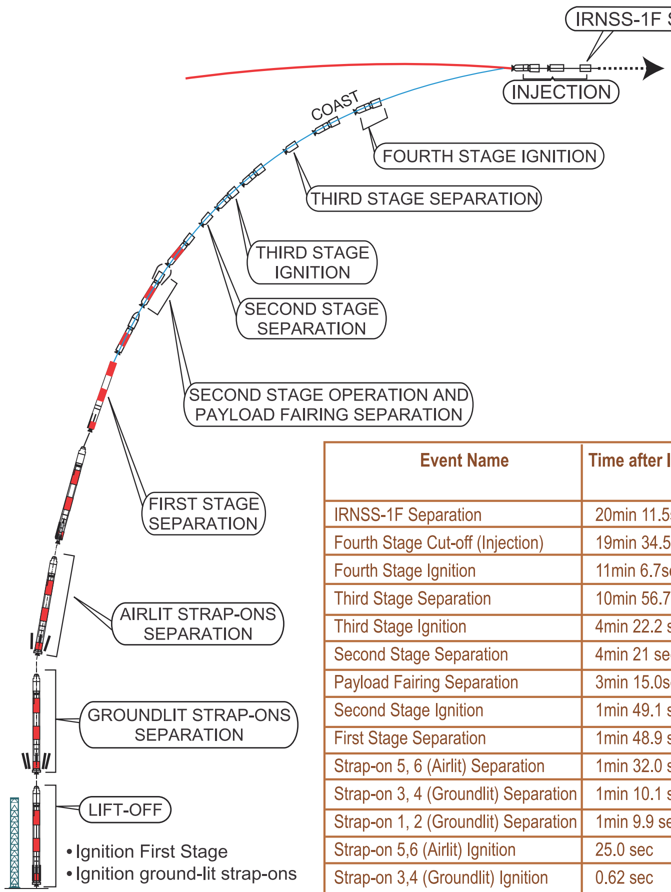
	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C32



IRNSS-1F in PSLV-C32 Envelope



Apogee	20,657 ± 675 km
Perigee	284 ± 5 km
Inclination	17.86 ± 0.2 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1F Separation	20min 11.5sec	488.9	9614.1
Fourth Stage Cut-off (Injection)	19min 34.5 sec	439.3	9655.0
Fourth Stage Ignition	11min 6.7sec	192.0	7726.8
Third Stage Separation	10min 56.7 sec	190.5	7728.7
Third Stage Ignition	4min 22.2 sec	134.8	5369.1
Second Stage Separation	4min 21 sec	134.5	5369.5
Payload Fairing Separation	3min 15.0sec	113.3	3554.8
Second Stage Ignition	1min 49.1 sec	56.1	2386.9
First Stage Separation	1min 48.9 sec	56.0	2387.4
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	40.8	2089.9
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	24.0	1481.2
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	23.9	1476.2
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.6	613.2
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.025	451.9
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.025	451.9
First Stage Ignition	0.00	0.025	451.9

PSLV-C32 Typical Flight Profile

Assembly of PSLV-C32 First stage in progress

Hoisting of PSLV-C32 Second stage during vehicle integration

IRNSS-1F

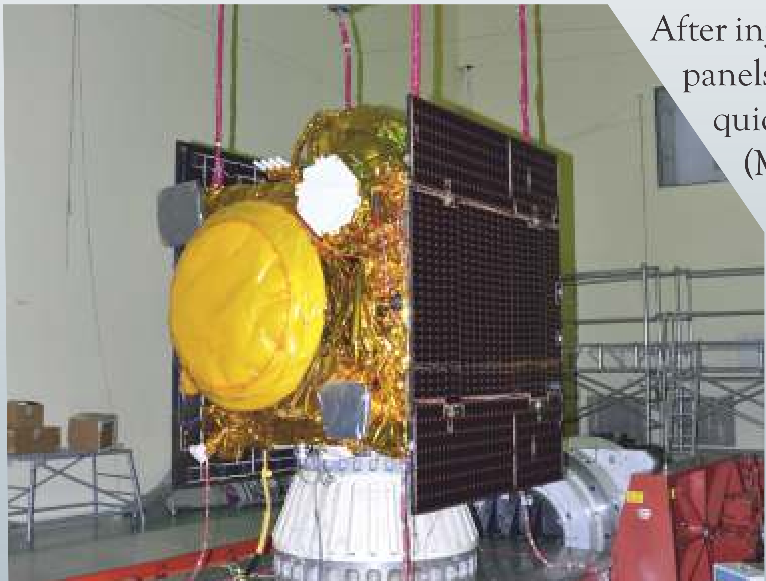
IRNSS-1F in Clean Room during its integeration

IRNSS-1F is the sixth navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A, 1B, 1C, 1D and 1E were launched by PSLV-C22, PSLV-C24, PSLV-C26, PSLV-C27 and PSLV-C31 in July 2013, April 2014, October 2014, March 2015 and January 2016 respectively. IRNSS-1F has a lift-off mass of 1425 kg. The configuration of IRNSS-1F is similar to that of IRNSS-1A, 1B, 1C, 1D and 1E.

The two solar arrays of IRNSS-1F consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference for the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1F maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.

IRNSS-1F being loaded into thermo-vacuum chamber

IRNSS-1F will be launched into a sub Geosynchronous Transfer Orbit (sub GTO) with a 284 km perigee (nearest point to Earth) and 20,657 km apogee (farthest point to Earth) with an inclination of 17.86 deg with respect to the equatorial plane.

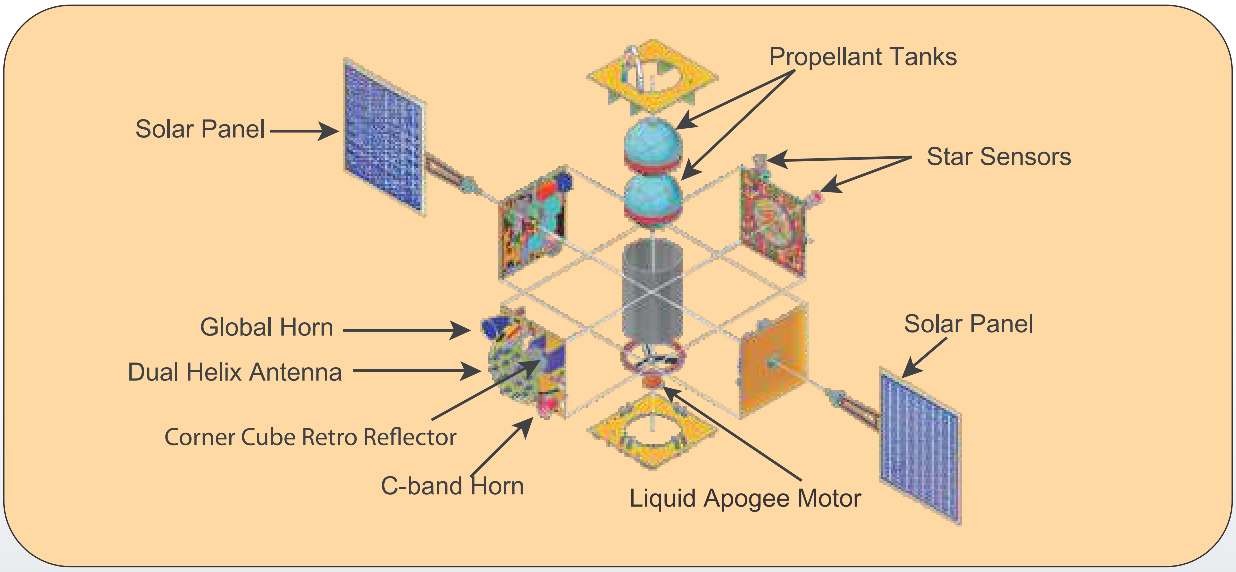


IRNSS-1F being readied for vibration test

After injection into this preliminary orbit, the two solar panels of IRNSS-1F are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of one manoeuvre at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the geostationary orbit at 32.5 deg E.

IRNSS-1F Salient features

ORBIT	Geostationary, at 32.5 deg East longitude
LIFT-OFF MASS	1425 kg
DRY MASS	598 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun & Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	12 years



IRNSS -1F Disassembled View

PAYLOADS:

IRNSS -1F carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1F will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1F consists of a C-band transponder which facilitates accurate determination of the range of the satellite. IRNSS-1F also carries Corner Cube Retro Reflectors for laser ranging.

IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is the primary service area of IRNSS. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS), which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS comprises of a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS-1A, 1B,1C ,1D and 1E, the first five satellites of the IRNSS constellation, have already started functioning from their designated orbital slots after extensive on-orbit test and evaluation to confirm their satisfactory performance.

The IRNSS Signal-in-Space Interface Control Document (ICD) for SPS version 1.0 was released in the official ISRO website http://irnss.isro.gov.in in October 2014. The information for a user to acquire, track and utilise the SPS navigation signals are provided in the ICD.

With the operationalisation of five spacecraft, proof-of-concept of an independent regional navigation satellite system over India has been demonstrated for the targeted position accuracy of better than 20 mtrs over 24 hours of the day. With the launch and operationalisation of IRNSS-1F, the sixth in the constellation, better position accuracy will be provided.

IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.

ISRO Navigation Centre at (INC) at Byalalu, the Nerve Centre of the IRNSS ground segment

Currently, IRNSS ground segment is operational on 24/7 basis with 13 Indian Range and Integrity Monitoring Stations (IRIMS), one IRNSS Network Timing Centre (IRNWT), one ISRO Navigation Centre (INC) and one Spacecraft Control Facility (SCF) with its data communication network. Along with the deployment of seven satellite constellation, the entire ground segment with two more IRIMS and one each of IRNWT, INC and SCF is planned to be established.

Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Vehicle tracking and fleet management
- Terrestrial navigation aid for hikers and travelers
- Disaster Management
- Integration with mobile phones
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers

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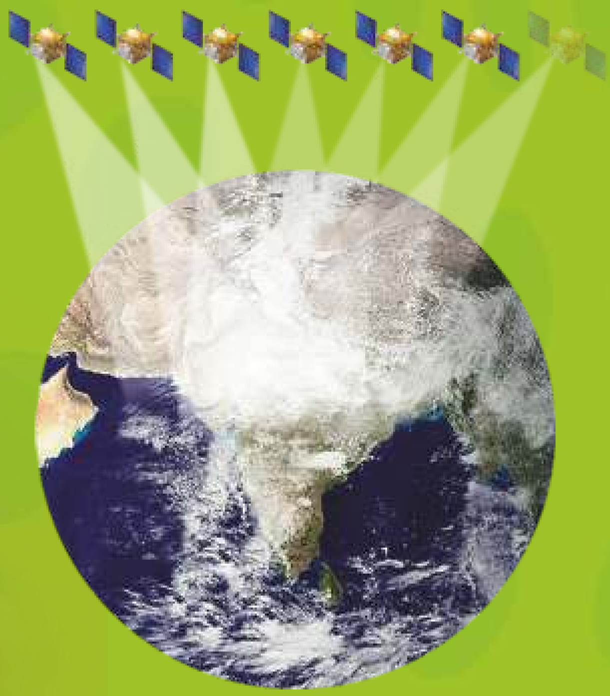
March 2016 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore

PSLV-C33
IRNSS-1G



PSLV-C33

PSLV-C33 at the First Launch Pad

The Polar Satellite Launch Vehicle, in its thirty fifth flight (PSLV-C33), will launch IRNSS-1G, the seventh satellite of the Indian Regional Navigation Satellite System (IRNSS) into a Sub-Geosynchronous Transfer Orbit (Sub-GTO). The launch will take place from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. As in the previous six launches of IRNSS satellites, PSLV-C33 will use 'XL' version of PSLV equipped with six strap-ons, each carrying 12 tons of propellant.

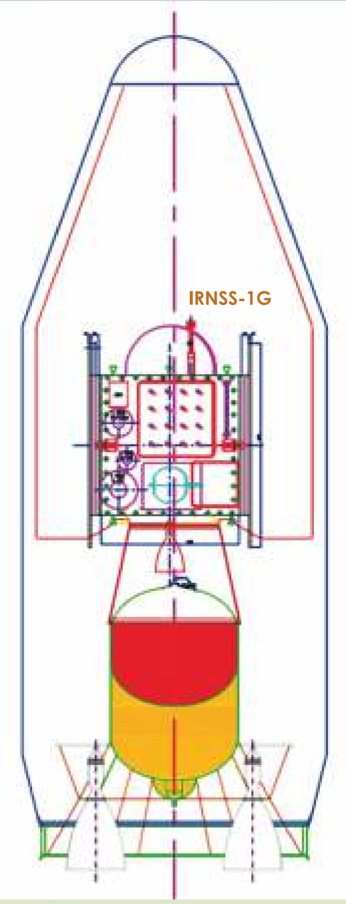
This is the thirteenth time 'XL' configuration is being flown. Besides launching six IRNSS satellites, PSLV-XL has also launched many other spacecraft including India's Mars Orbiter spacecraft, the multi-wavelength observatory ASTROSAT, Radar Imaging satellite RISAT-1 and the Communication satellite GSAT-12. This apart, PSLV-XL has successfully placed five satellites from United Kingdom into orbit in a single commercial mission. Through these launches, PSLV has repeatedly proved its reliability and versatility.

PSLV-C33 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

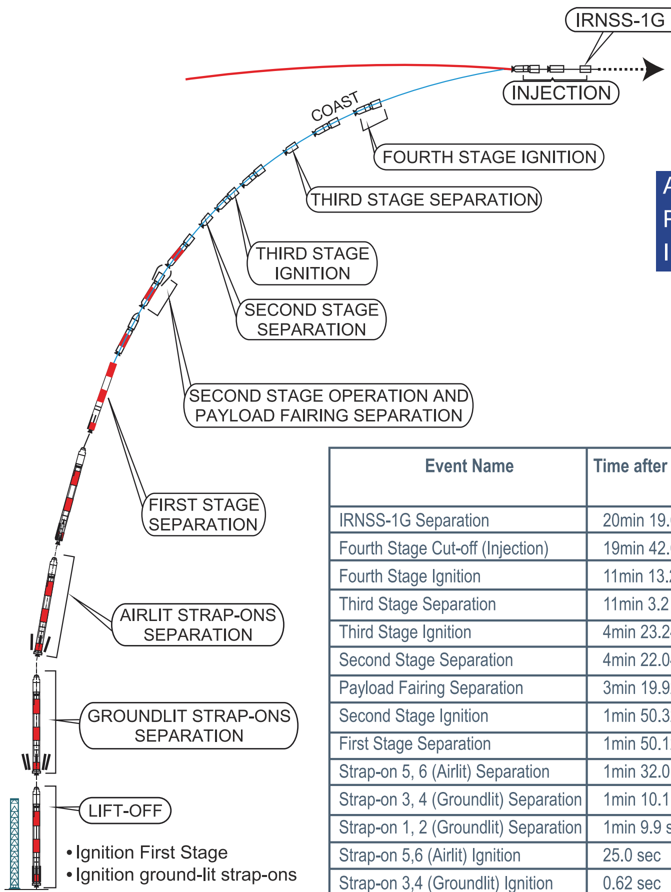
	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C33



IRNSS-1G in PSLV-C33 Envelope



Apogee	20,657 ± 675 km
Perigee	284 ± 5 km
Inclination	17.86 ± 0.2 deg

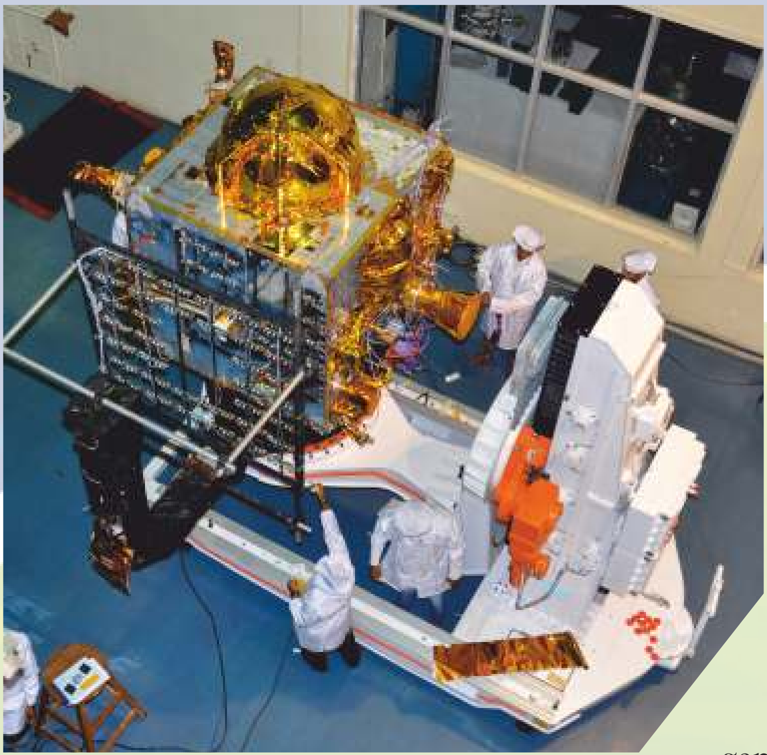
Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
IRNSS-1G Separation	20min 19.02sec	497.807	9606.45
Fourth Stage Cut-off (Injection)	19min 42.02 sec	446.676	9646.21
Fourth Stage Ignition	11min 13.2sec	192.225	7723.84
Third Stage Separation	11min 3.2 sec	190.632	7725.74
Third Stage Ignition	4min 23.24 sec	132.316	5373.49
Second Stage Separation	4min 22.04 sec	132.089	5373.89
Payload Fairing Separation	3min 19.92 sec	112.610	3643.63
Second Stage Ignition	1min 50.32 sec	55.823	2394.65
First Stage Separation	1min 50.12 sec	55.653	2395.16
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	39.887	2059.81
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	23.751	1449.94
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	23.623	1445.17
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.694	616.32
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0.00	0.024	451.89

PSLV-C33 Typical Flight Profile

PSLV-C33 core stage integrated above the launch pedestal

Second stage of PSLV-C33 being prepared for vehicle integration

IRNSS-1G



IRNSS-1G being prepared for a prelaunch test

IRNSS-1G is the seventh navigation satellite of the seven satellites constituting the IRNSS space segment. Its predecessors, IRNSS-1A, 1B, 1C, 1D, 1E and 1F were launched by PSLV-C22, PSLV-C24, PSLV-C26, PSLV-C27, PSLV-C31 and PSLV-C32 in July 2013, April 2014, October 2014, March 2015, January 2016 and March 2016 respectively. Like all other IRNSS satellites, IRNSS-1G also has a lift-off mass of 1425 kg. The configuration of IRNSS-1G too is the same as IRNSS-1A, 1B, 1C, 1D, 1E and 1F.

The two solar panels of IRNSS-1G consisting of Ultra Triple Junction solar cells generate about 1660 Watts of electrical power. Sun and Star sensors as well as gyroscopes provide orientation reference to the satellite. Special thermal control schemes have been designed and implemented for some of the critical elements such as atomic clocks. The Attitude and Orbit Control System (AOCS) of IRNSS-1G maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters. Its propulsion system consists of a Liquid Apogee Motor (LAM) and thrusters.

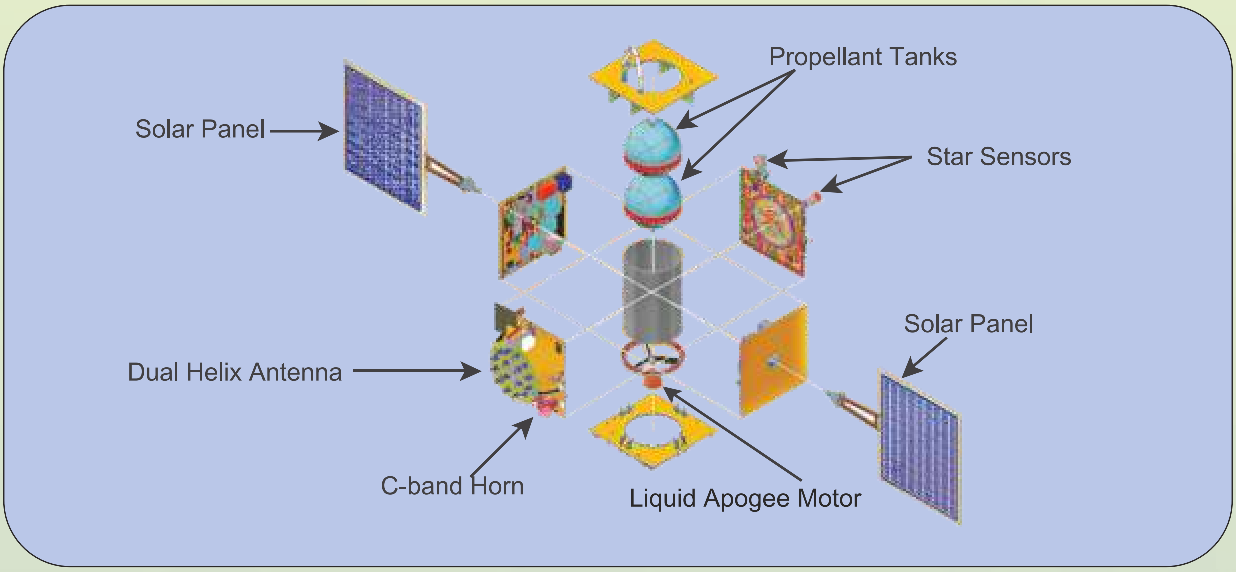
IRNSS-1G will be launched into a sub Geosynchronous Transfer Orbit (sub-GTO) with a 284 km perigee (nearest point to Earth) and 20,657 km apogee (farthest point to Earth) with an inclination of 17.86 deg with respect to the equatorial plane.

After injection into this preliminary orbit, the two solar panels of IRNSS-1G are automatically deployed in quick succession and the Master Control Facility (MCF) at Hassan takes control of the satellite and performs the initial orbit raising manoeuvres consisting of one manoeuvre at perigee (nearest point to earth) and three at apogee (farthest point to earth). For these manoeuvres, the Liquid Apogee Motor (LAM) of the satellite is used, thereby finally placing it in the geostationary orbit at 129.5 deg E.

IRNSS-1G in clean room at SDSC SHAR

IRNSS-1G Salient features

ORBIT	Geostationary, at 129.5 deg East longitude
LIFT-OFF MASS	1425 kg
DRY MASS	598 kg
PHYSICAL DIMENSIONS	1.58 metre x 1.50 metre x 1.50 metre
POWER	Two solar panels generating 1660 W, one Lithium-ion battery of 90 Ampere-Hour capacity
PROPULSION	440 Newton Liquid Apogee Motor, twelve 22 Newton Thrusters
CONTROL SYSTEM	Zero momentum system, orientation input from Sun and Star Sensors and Gyroscopes; Reaction Wheels, Magnetic Torquers and 22 Newton thrusters as actuators
MISSION LIFE	12 years



IRNSS -1G Disassembled View

PAYLOADS:

Like its other IRNSS predecessors, IRNSS-1G also carries two types of payloads – navigation payload and ranging payload. The navigation payload of IRNSS-1G will transmit navigation service signals to the users. This payload will be operating in L5 band (1176.45 MHz) and S band (2492.028 MHz). A highly accurate Rubidium atomic clock is part of the navigation payload of the satellite. The ranging payload of IRNSS-1G consists of a C-band transponder which facilitates accurate determination of the range of the satellite.

IRNSS Overview:

IRNSS is an independent regional navigation satellite system being developed by India. It is designed to provide accurate position information service to users in India as well as the region extending up to 1500 km from its boundary, which is the primary service area of IRNSS. The Extended Service Area lies between primary service area and area enclosed by the rectangle from Latitude 30 deg South to 50 deg North, Longitude 30 deg East to 130 deg East. IRNSS will provide two types of services, namely, Standard Positioning Service (SPS), which is provided to all the users and Restricted Service (RS), which is an encrypted service provided only to the authorised users. The IRNSS System is expected to provide a position accuracy of better than 20 m in the primary service area.

IRNSS comprises a space segment and a ground segment. The IRNSS space segment consists of seven satellites, with three satellites in geostationary orbit and four satellites in inclined geosynchronous orbit. IRNSS-1A, 1B,1C ,1D, 1E and 1F, the first six satellites of the IRNSS constellation, have already started functioning from their designated orbital slots after extensive on-orbit test and evaluation to confirm their satisfactory performance.

The IRNSS Signal-in-Space Interface Control Document (ICD) for SPS version 1.0 was released in the official ISRO website http://irnss.isro.gov.in in October 2014. The information for a user to acquire, track and utilise the SPS navigation signals are available in the ICD.

With the operationalisation of six satellites, proof-of-concept of an independent regional navigation satellite system over India has been demonstrated for the targeted position accuracy which is much better than 20 mtrs over 24 hours of the day. With the launch and operationalisation of IRNSS-1G, the seventh in the constellation, the completion of IRNSS constellation will be achieved.

IRNSS ground segment is responsible for navigation parameter generation and transmission, satellite control, ranging and integrity monitoring as well as time keeping.

ISRO Navigation Centre at (INC) at Byalalu, the Nerve Centre of the IRNSS ground segment

Currently, IRNSS ground segment is operational on 24/7 basis with 13 Indian Range and Integrity Monitoring Stations (IRIMS), one IRNSS Network Timing Centre (IRNWT), one ISRO Navigation Centre (INC) and one Spacecraft Control Facility (SCF) with its data communication network. The entire ground segment with two more IRIMS and one each of IRNWT, INC and SCF is planned to be completed in future.

Applications of IRNSS:

- Terrestrial, Aerial and Marine Navigation
- Vehicle tracking and fleet management
- Terrestrial navigation aid for hikers and travelers
- Disaster Management
- Integration with mobile phones
- Mapping and Geodetic data capture
- Visual and voice navigation for drivers

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April 2016 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore

PSLV-C34
CARTOSAT

SATHYABAMASAT SWAYAM

LAPAN-A3 [Indonesia] BIROS [Germany] M3MSat [Canada]

SkySat Gen2-1 [USA] GHGSat-D [Canada] Dove Satellites (Twelve) [USA]

PSLV-C34

PSLV-C34 at the Second Launch Pad

India's Polar Satellite Launch Vehicle, in its thirty sixth flight (PSLV-C34), will launch the 727.5 kg Cartosat-2 series satellite for earth observation and 19 co-passenger satellites together weighing about 560 kg at lift–off into a 505 km polar Sun Synchronous Orbit (SSO). PSLV-C34 will be launched from the Second Launch Pad (SLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. It will be the fourteenth flight of PSLV in 'XL' configuration (with the use of solid strap-on motors).

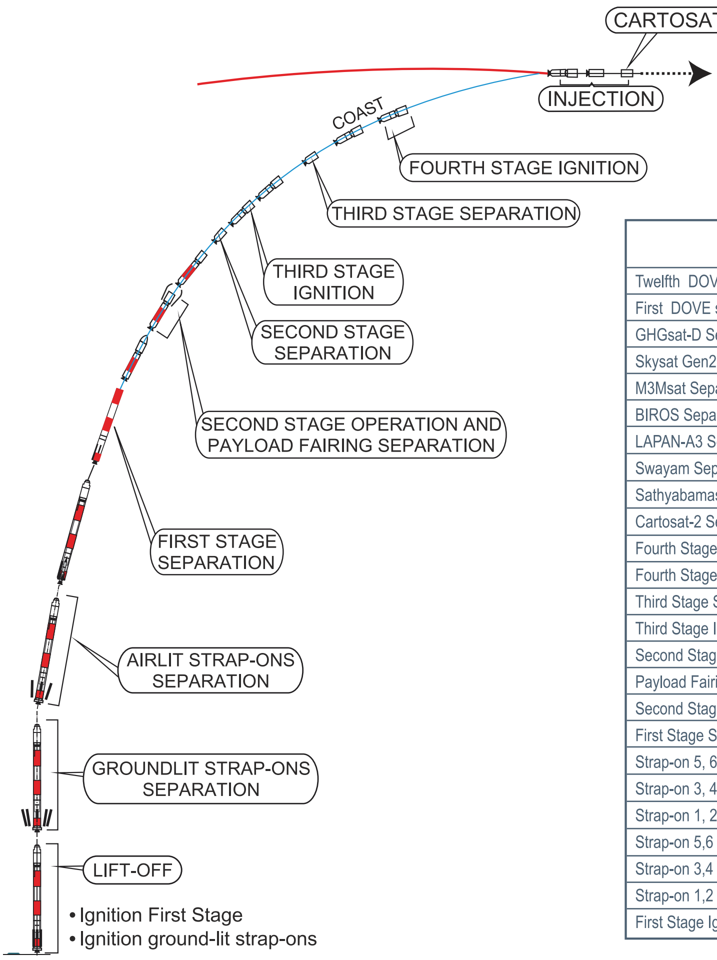
The co-passenger satellites are from USA, Canada, Germany and Indonesia as well as two satellites from Indian University/Academic Institute. The total weight of all the 20 satellites carried onboard PSLV-C34 is about 1288 kg.

PSLV-C34 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

	Stage-1	*Stage-2*	*Stage-3*	*Stage-4*
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

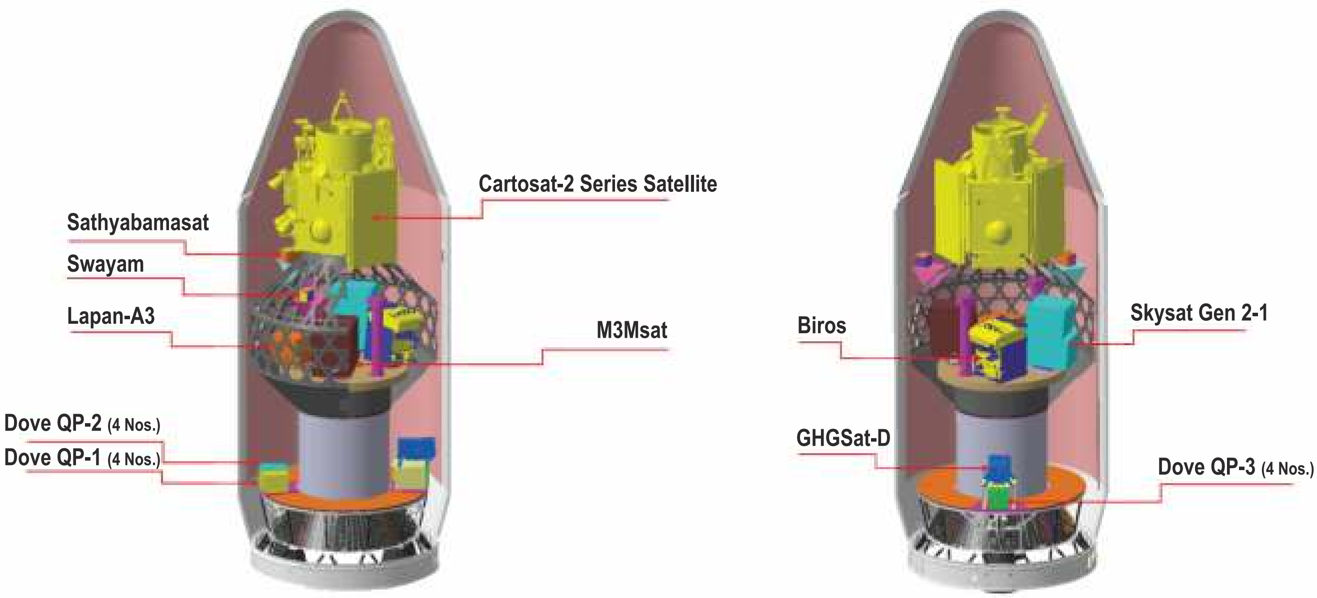
PSLV-C34



Height: 505 km
Inclination: 97.48 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
Twelfth DOVE satellite (QP2.4) Separation	26 min 30.36 sec	526.877	7601.11
First DOVE satellite (QP3.1) Separation	20 min 20.36 sec	519.202	7604.70
GHGsat-D Separation	19 min 20.36 sec	517.859	7605.34
Skysat Gen2-1 Separation	19 min 0.58 sec	517.422	7605.54
M3Msat Separation	19 min 0.36 sec	517.417	7605.55
BIROS Separation	18 min 22.58 sec	516.593	7605.94
LAPAN-A3 Separation	18 min 22.36 sec	516.588	7605.94
Swayam Separation	17 min 42.80 sec	515.748	7606.25
Sathyabamasat Separation	17 min 42.36 sec	515.739	7606.26
Cartosat-2 Series Satellite Separation	17 min 7.36 sec	515.021	7606.61
Fourth Stage Cut-off (Injection)	16 min 30.36 sec	514.289	7602.69
Fourth Stage Ignition	8min 17.22 sec	423.779	5925.82
Third Stage Separation	8min 7.22 sec	417.233	5935.29
Third Stage Ignition	4min 22.46 sec	217.235	4125.13
Second Stage Separation	4min 21.26 sec	216.043	4127.79
Payload Fairing Separation	2min 35.02 sec	115.457	2468.68
Second Stage Ignition	1min 48.92 sec	66.087	2170.96
First Stage Separation	1min 48.72 sec	65.862	2171.78
Strap-on 5, 6 (Airlit) Separation	1min 32.0 sec	46.906	1897.75
Strap-on 3, 4 (Groundlit) Separation	1min 10.1 sec	26.762	1331.96
Strap-on 1, 2 (Groundlit) Separation	1min 9.9 sec	26.606	1327.26
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.748	576.40
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.025	451.92
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.025	451.92
First Stage Ignition	0.00	0.025	451.92

PSLV-C34 Typical Flight Profile



Two cross sectional views of PSLV-C34 payload fairing

Primary Satellite

The Cartosat-2 series satellite is the primary satellite carried by PSLV-C34. This satellite is similar to the earlier Cartosat-2, 2A and 2B. After its injection into a 505 km polar Sun Synchronous Orbit by PSLV-C34, the satellite will be brought to operational configuration following which it will begin providing regular remote sensing services using its Panchromatic and Multispectral cameras.

The imagery sent by the satellite will be useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, precision study, change detection to bring out geographical and manmade features and various other Land Information System (LIS) and Geographical Information System (GIS) applications.

Salient features

Satellite mass	727.5 Kg
Orbit type	Circular polar Sun Synchronous
Orbit height	505 km
Orbit inclination	97.48 degree
Local time of Equator crossing	9:30 am
Power	Solar arrays generating 986 Watts; Two Li- Ion batteries
Attitude control	Reaction wheels, Magnetic torquers and Hydrazine thrusters
Design life	5 years

Co-passenger Satellites

International Customer Satellites

LAPAN-A3 [Indonesia]

Mass: 120 kg

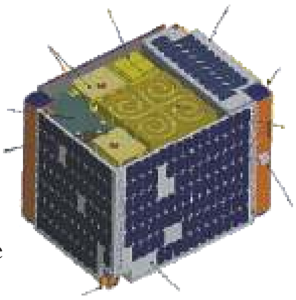
LAPAN-A3 is an Indonesian microsatellite for Earth observation (multi-spectral remote sensing) for land use, natural resource and environment monitoring.

M3MSat [Canada]

Mass: 85 kg

M3MSat (Maritime Monitoring and Messaging Micro-satellite) is a technology demonstration mission jointly funded and managed by Defense Research and Development Canada (DRDC) and the Canadian Space Agency (CSA).

The satellite's primary mission is the collection and study of Automatic Identification System (AIS) signals from low-Earth orbit.

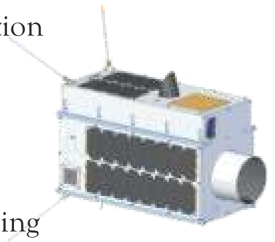


GHGSat-D [Canada]

Mass: 25.5 kg

GHGSat-D is an Earth observation Satellite built by Space Flight Laboratory at the University of Toronto Institute for Aerospace Studies.

GHGSat-D is meant for measuring atmospheric concentration of greenhouse gases (Carbon Dioxide and Methane).



BIROS [Germany]

Mass: 130 kg

BIROS (Berlin Infrared Optical System) is a small scientific satellite from the German Aerospace Center (DLR). The main mission objective is the remote sensing of high temperature events.

SkySat Gen2-1 [USA]

Mass: 110 kg

SkySat Gen2-1 ("SkySat-3") is a small Earth imaging satellite designed and built by Terra Bella, a Google company based in Mountain View, California, USA.

The satellite will be capable of capturing sub-meter resolution imagery and HD video.

Dove Satellites [USA]

Mass: 4.7 kg each

The Planet Labs Dove Satellites (Flock-2P) are Earth imaging satellites. A total of **twelve** Dove satellites are carried in this mission inside three QuadPack dispensers.

University/Academic Institute Satellites from India

SATHYABAMASAT

Mass: 1.5 kg

{from Sathyabama University, Chennai}

Mission objectives:
To collect data on green house gases (Water vapor, Carbon monoxide, Carbon dioxide, Methane and Hydrogen fluoride).

SWAYAM

Mass: 1 kg

{from College Of Engineering, Pune}

Mission objectives:
To provide point to point messaging services to the HAM Community.

Satellites of other countries launched by PSLV

SL. NO.	NAME	COUNTRY	DATE OF LAUNCH	MASS (kg)	LAUNCH VEHICLE
1	DLR-TUBSAT	GERMANY	26-05-1999	45	PSLV-C2
2	KITSAT-3	REPUBLIC OF KOREA	26-05-1999	110	PSLV-C2
3	BIRD	GERMANY	22-10-2001	92	PSLV-C3
4	PROBA	BELGIUM	22-10-2001	94	PSLV-C3
5	LAPAN-TUBSAT	INDONESIA	10-01-2007	56	PSLV-C7
6	PEHUENSAT-1	ARGENTINA	10-01-2007	6	PSLV-C7
7	AGILE	ITALY	23-04-2007	350	PSLV-C8
8	TECSAR	ISRAEL	21-01-2008	300	PSLV-C10
9	CAN-X2	CANADA	28-04-2008	7	PSLV-C9
10	CUTE-1.7	JAPAN	28-04-2008	5	PSLV-C9
11	DELFI-C3	THE NETHERLANDS	28-04-2008	6.5	PSLV-C9
12	AAUSAT-II	DENMARK	28-04-2008	3	PSLV-C9
13	COMPASS-I	GERMANY	28-04-2008	3	PSLV-C9
14	SEEDS	JAPAN	28-04-2008	3	PSLV-C9
15	NLS5	CANADA	28-04-2008	16	PSLV-C9
16	RUBIN-8	GERMANY	28-04-2008	8	PSLV-C9
17	CUBESAT-1	GERMANY	23-09-2009	1	PSLV-C14
18	CUBESAT-2	GERMANY	23-09-2009	1	PSLV-C14
19	CUBESAT-3	TURKEY	23-09-2009	1	PSLV-C14
20	CUBESAT-4	SWITZERLAND	23-09-2009	1	PSLV-C14
21	RUBIN-9.1	GERMANY	23-09-2009	1	PSLV-C14
22	RUBIN-9.2	GERMANY	23-09-2009	1	PSLV-C14
23	ALSAT-2A	ALGERIA	12-07-2010	116	PSLV-C15
24	NLS6.1 AISSAT-1	CANADA	12-07-2010	6.5	PSLV-C15
25	NLS6.2 TISAT-1	SWITZERLAND	12-07-2010	1	PSLV-C15
26	X-SAT	SINGAPORE	20-04-2011	106	PSLV-C16
27	VesselSat-1	LUXEMBOURG	12-10-2011	28.7	PSLV-C18
28	SPOT-6	FRANCE	09-09-2012	712	PSLV-C21
29	PROITERES	JAPAN	09-09-2012	15	PSLV-C21
30	SAPPHIRE	CANADA	25-02-2013	148	PSLV-C20
31	NEOSSAT	CANADA	25-02-2013	74	PSLV-C20
32	NLS8.1	AUSTRIA	25-02-2013	14	PSLV-C20
33	NLS8.2	AUSTRIA	25-02-2013	14	PSLV-C20
34	NLS8.3	DENMARK	25-02-2013	3	PSLV-C20
35	STRAND-1	UNITED KINGDOM	25-02-2013	6.5	PSLV-C20
36	SPOT-7	FRANCE	30-06-2014	714	PSLV-C23
37	AISAT	GERMANY	30-06-2014	14	PSLV-C23
38	NLS7.1(CAN-X4)	CANADA	30-06-2014	15	PSLV-C23
39	NLS7.2(CAN-X5)	CANADA	30-06-2014	15	PSLV-C23
40	VELOX-1	SINGAPORE	30-06-2014	7	PSLV-C23
41	DMC3-1	UNITED KINGDOM	10-07-2015	447	PSLV-C28
42	DMC3-2	UNITED KINGDOM	10-07-2015	447	PSLV-C28
43	DMC3-3	UNITED KINGDOM	10-07-2015	447	PSLV-C28
44	CBNT-1	UNITED KINGDOM	10-07-2015	91	PSLV-C28
45	De-OrbitSail	UNITED KINGDOM	10-07-2015	7	PSLV-C28
46	LAPAN-A2	INDONESIA	28-09-2015	76	PSLV-C30
47	NLS-14 (Ev9)	CANADA	28-09-2015	14	PSLV-C30
48	LEMUR	USA	28-09-2015	*	PSLV-C30
49	LEMUR	USA	28-09-2015	*	PSLV-C30
50	LEMUR	USA	28-09-2015	*	PSLV-C30
51	LEMUR	USA	28-09-2015	*	PSLV-C30
52	TeLEOS-1	SINGAPORE	16-12-2015	400	PSLV-C29
53	Kent Ridge-1	SINGAPORE	16-12-2015	78	PSLV-C29
54	VELOX-C1	SINGAPORE	16-12-2015	123	PSLV-C29
55	VELOX-II	SINGAPORE	16-12-2015	13	PSLV-C29
56	Galassia	SINGAPORE	16-12-2015	3.4	PSLV-C29
57	Athenoxat-1	SINGAPORE	16-12-2015	-	PSLV-C29

June 2016 Design: info@smartworks.in | Printed by: M/s. Aditya Printers, Bangalore.

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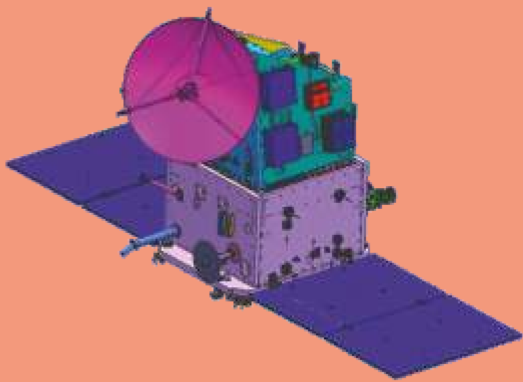


PSLV-C35
SCATSAT-1

PISAT **PRATHAM**

ALSAT-1B (Algeria) **ALSAT-2B** (Algeria) **ALSAT-1N** (Algeria)

NLS-19 (Canada) **Pathfinder-1** (USA)

PSLV-C35

PSLV-C35 at the First Launch Pad

India's Polar Satellite Launch Vehicle in its thirty seventh flight (PSLV-C35), will launch the 371 kg SCATSAT-1 for weather related studies and seven co-passenger satellites together weighing about 304 kg at lift-off. The co-passenger satellites are from Algeria, Canada and the USA as well as two satellites from Indian University/Academic Institute. The total weight of all the eight satellites carried onboard PSLV-C35 is about 675 kg.

Of the eight satellites carried by PSLV-C35, SCATSAT-1 is launched into a 730 km polar Sun Synchronous Orbit (SSO) inclined at an angle of 98.1 degree to the equator whereas the two Indian University/Academic Institute satellites and the five satellites from abroad will be placed in a 689 km polar orbit of 98.21 degree inclination later. This is the first mission of PSLV in which it will be launching its payloads into two different orbits.

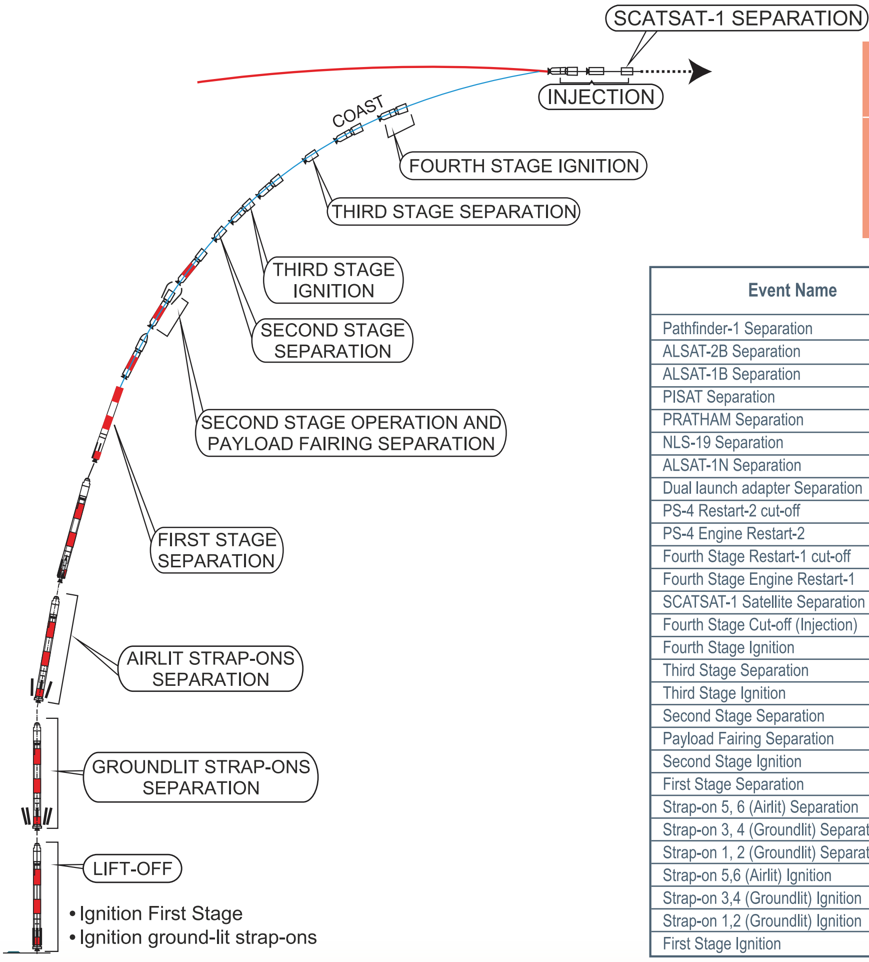
PSLV-C35 will be launched from the First Launch Pad (FLP) of Satish Dhawan Space Centre SHAR, Sriharikota. This will be the fifteenth flight of PSLV in 'XL' configuration (with the use of solid strap-on motors).

PSLV-C35 at a glance (Vehicle lift-off Mass: 320 tonne Height: 44.4 m)

	Stage-1	*Stage-2*	*Stage-3*	*Stage-4*
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Solid (HTPB based)	Liquid (UH25 + N_2O_4)	Solid (HTPB based)	Liquid (MMH + MON-3)
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

HTPB : Hydroxyl Terminated Poly Butadiene
UH25 : Unsymmetrical Dimethyl Hydrazine + 25% Hydrazine Hydrate
N_2O_4 : Nitrogen Tetroxide
MMH : Mono Methyl Hydrazine, MON-3: Mixed Oxides of Nitrogen

PSLV-C35

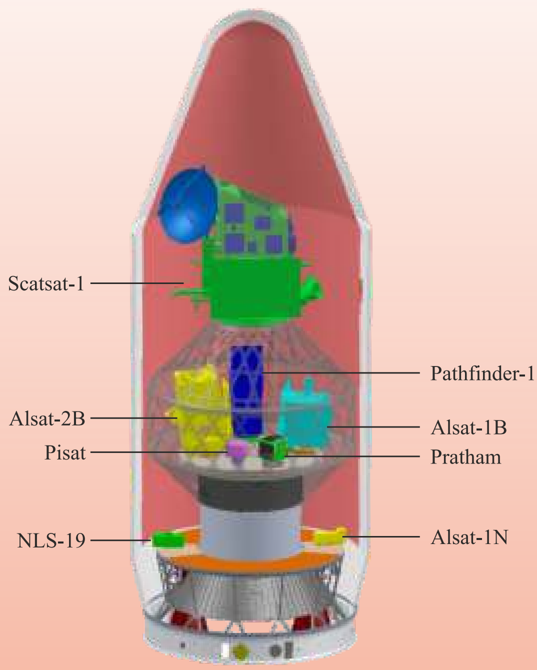


Height: 730 km (SCATSAT-1)
Inclination: 98.1 deg

Height: 689 km (ALSAT-1N, NLS-19, PRATHAM, PISAT, ALSAT-1B, ALSAT-2B, Pathfinder-1)
Inclination: 98.21 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
Pathfinder-1 Separation	2 hr 15 min 32.96 sec	689.600	7520.90
ALSAT-2B Separation	2 hr 15 min 17.96 sec	689.647	7520.91
ALSAT-1B Separation	2 hr 15 min 2.96 sec	689.690	7520.93
PISAT Separation	2 hr 14 min 52.96 sec	689.715	7520.94
PRATHAM Separation	2 hr 14 min 42.96 sec	689.737	7520.94
NLS-19 Separation	2 hr 13 min 22.96 sec	689.826	7521.02
ALSAT-1N Separation	2 hr 13 min 12.96 sec	689.825	7521.03
Dual launch adapter Separation	2 hr 12 min 42.96 sec	689.807	7521.05
PS-4 Restart-2 cut-off	2 hr 12 min 5.96 sec	689.752	7521.18
PS-4 Engine Restart-2	2 hr 11 min 46.52 sec	689.731	7527.63
Fourth Stage Restart-1 cut-off	1 hr 22 min 58.56 sec	739.306	7475.54
Fourth Stage Engine Restart-1	1 hr 22 min 38.02 sec	739.314	7489.37
SCATSAT-1 Satellite Separation	17 min 32.84 sec	730.758	7490.68
Fourth Stage Cut-off (Injection)	16 min 55.84 sec	730.092	7485.00
Fourth Stage Ignition	12min 26.52 sec	680.576	6184.49
Third Stage Separation	9min 47.80 sec	580.877	6313.34
Third Stage Ignition	4min 25.40 sec	223.638	4141.24
Second Stage Separation	4min 24.20 sec	222.233	4144.35
Payload Fairing Separation	2min 41.14 sec	115.464	2400.74
Second Stage Ignition	1min 52.94 sec	65.491	2027.02
First Stage Separation	1min 52.74 sec	65.276	2027.86
Strap-on 5, 6 (Airlit) Separation	1min 30.0 sec	40.911	1642.71
Strap-on 3, 4 (Groundlit) Separation	1min 8.1 sec	22.894	1147.86
Strap-on 1, 2 (Groundlit) Separation	1min 7.9 sec	22.756	1143.62
Strap-on 5,6 (Airlit) Ignition	25.00 sec	2.392	546.40
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.024	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.024	451.89
First Stage Ignition	0.00	0.024	451.89

PSLV-C35 Typical Flight Profile



Satellite accommodation details inside the payload faring of PSLV-C35

Integration of strap-ons to PSLV-C35 core stage at Mobile Service Tower

Primary Satellite

SCATSAT-1 is the primary satellite carried by PSLV-C35. The mission objectives of SCATSAT-1 are to help provide weather forecasting services to the user communities through the generation of wind vector products for weather forecasting, cyclone detection and tracking. SCATSAT-1 is a continuity mission for Scatterometer payload carried by the earlier Oceansat-2 satellite.

The Ku-band scatterometer payload carried by SCATSAT-1 has enhanced features compared to the similar one carried by Oceansat-2 launched in 2009.

The SCATSAT-1 structure has IMS-2 satellite bus heritage. The satellite's thermal control is achieved with the use of passive thermal elements like Optical Solar Reflectors, Multi Layer Insulation blanket, paints and heat pipe embedded panels. The two solar arrays of SCATSAT-1 generate about 750 Watts of electrical power. Sun and Star sensors as well as magnetometers and miniaturised Inertial Reference Unit (IRU) provide precise orientation reference to the satellite. The Attitude and Orbit Control System (AOCS) of SCATSAT-1 maintains the satellite's orientation with the help of reaction wheels, magnetic torquers and thrusters.

After its injection into the 730 km polar Sun Synchronous Orbit (SSO) by PSLV-C35, the satellite will be brought to the final operational configuration following which it will begin providing regular weather forecasting related inputs.

SCATSAT-1undergoing a prelaunch test

Salient Features

Satellite mass	371 Kg
Orbit type	Circular polar Sun Synchronous
Orbit height	720 km
Orbit inclination	98.1 degree
Local time of Equator crossing	9:20 am
Power	Solar arrays generating 750 Watts; 28 Ah Li- Ion battery
Attitude control	Reaction wheels, Magnetic torquers and Hydrazine thrusters
Design life	5 years
Data Transmission	X-band
On-board data storage	Solid State Recorder with 32 GB capacity

Co-passenger Satellites

International Customer Satellites

ALSAT-1B (Algeria)

Mass: 103 kg

ALSAT-1B is an Algerian earth orbservation satellite based on SSTL-100 platform for monitoring agriculture, environment and disasters

Pathfinder-1 (USA)

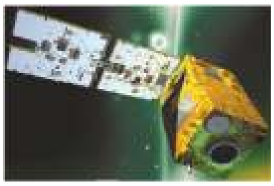
Mass: 44 kg

Pathfinder-1 is a commercial high resolution imaging microsatellite

ALSAT-2B (Algeria)

Mass: 117 kg

ALSAT-2B is a high resolution remote sensing satellite with panchromatic and multispectral imaging capability



NLS-19 (Canada)

Mass: 8 kg

NLS-19 (CAN X-7) is a technology demonstration nanosatellite built to perform experiments to help reduce space debris and for tracking commercial aircraft

ALSAT-1N (Algeria)

Mass: 7 kg

ALSAT-1N is a technology demonstration nanosatellite built as part of the programme for Algerian students

University/Academic Institute Satellites from India

PRATHAM

Mass: 10 kg

(from IIT, Bombay)

Mission Objectives: To estimate the Total Electron Count (TEC) with a resolution of 1km x 1km location grid

PISAT

Mass: 5.25 kg

(from PES University, Bangalore and its consortium)

Mission Objectives: Design and develop a Nanosatellite for remote sensing applications

From Oscat to SCATSAT-1

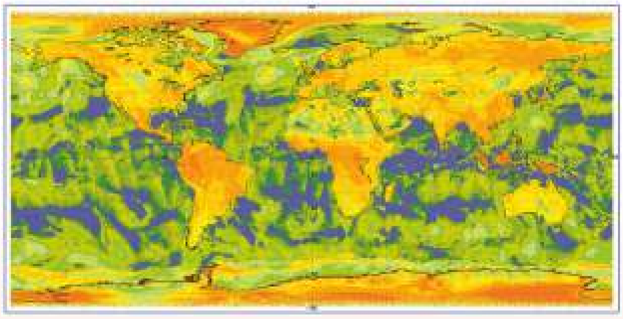
The Oceansat-II Scatterometer (popularly known as 'Oscat') is ISRO's first microwave remote-sensing sensor launched on September 23, 2009.

Oscat was also the only wind-sensing Ku-band scanning pencil-beam Scatterometer in operation during its lifetime (September 2009 to March 2014). It turned out to be a globally significant and useful mission in the areas of wind-retrieval, weather-forecasting, cyclone-tracking and prediction. As an example, the landfall of Phailin Cyclone in the Odisha coast was accurately predicted well in advance based on Oscat observations and thus loss of human life could be avoided.

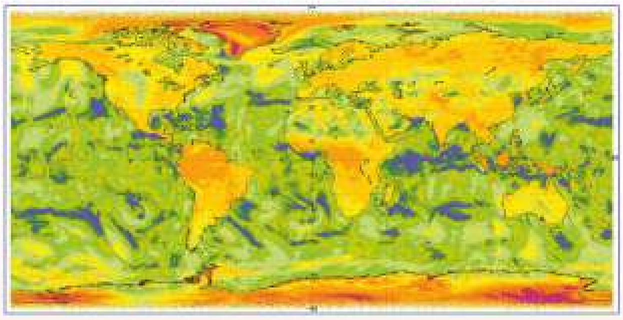
Oscat data were routinely disseminated to international agencies like EUMETSAT, KNMI, NASA, NOAA and ECMWF apart from Indian users. The instrument has been appreciated by the users for the quality and stability of data it provided.

SCATSAT-1 is a quick replacement mission of Oscat. Although a follow-on mission, significant improvements have been incorporated in the hardware configuration based on lessons learnt from Oscat. Also, the payload has been characterised with the objective of achieving data quality for Climate Data Records, apart from facilitating routine meteorological applications.

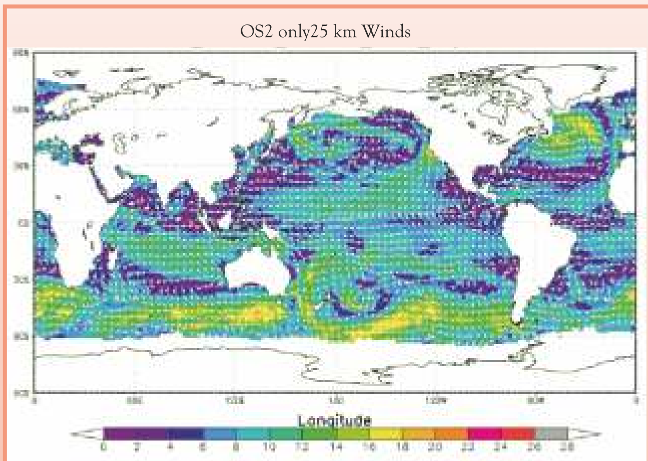
Global Radar Backscatter Images from OSCAT



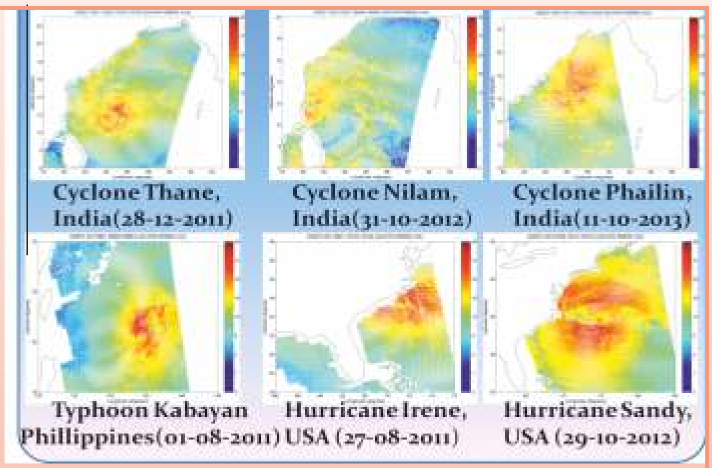
HH Polarisation



VV Polarisation



Global Wind Retrievals



Major Cyclones Captured by OSCAT

Indian Space Research Organisation
Publications and Public Relations
ISRO Headquarters, Antariksh Bhavan
New BEL Road, Bangalore - 560 231, India.
www.isro.gov.in

Sept. 2016 Design: info@smartworks.in
Printed by: M/s. Aditya Printers, Bangalore

PSLV-C38

CARTOSAT-2 Series Satellite

PSLV-C38 at the First Launch Pad

The Mission

India's Polar Satellite Launch Vehicle, in its fortieth flight (PSLV-C38), will launch the 712 kg Cartosat-2 Series Satellite for earth observation and 30 co-passenger satellites together weighing about 243 kg at lift-off into a 505 km polar Sun Synchronous Orbit (SSO). PSLV-C38 will be launched from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. It will be the seventeenth flight of PSLV in 'XL' configuration (with the use of solid strap-on motors).

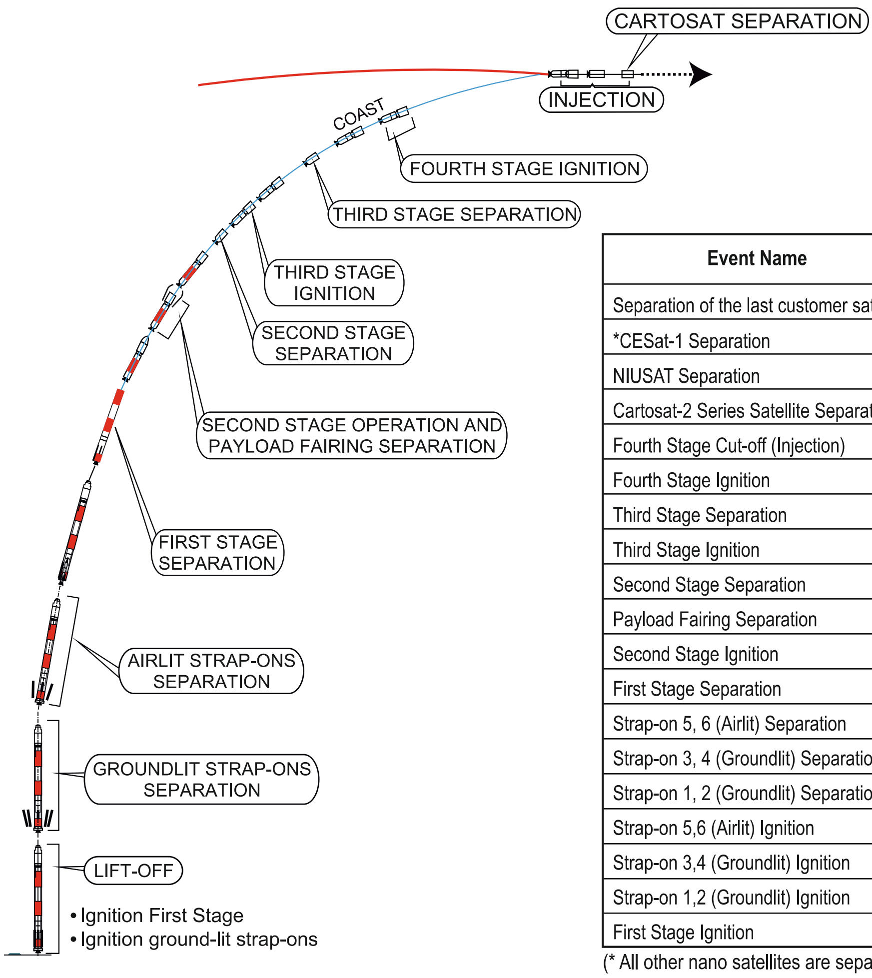
The co-passenger satellites comprise 29 Nano satellites from 14 countries, viz., Austria, Belgium, Chile, Czech Republic, Finland, France, Germany, Italy, Japan, Latvia, Lithuania, Slovakia, United Kingdom and The United States of America as well as one Nano satellite from India. The total weight of all the 31 satellites carried onboard PSLV-C38 is about 955 kg.

The 29 International customer Nano satellites are being launched as part of the commercial arrangements between Antrix Corporation Limited (Antrix), a Government of India company under Department of Space (DOS) and the commercial arm of ISRO and the International customers.

PSLV-C38 at a glance (lift-off Mass: 320 tonne Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Composite solid	Earth Storable Liquid	Composite solid	Earth Storable Liquid
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.3
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

PSLV-C38/CARTOSAT-2 SERIES SATELLITE



Height: 505 km
Inclination: 97.44 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
Separation of the last customer satellite	23 min 18.94 sec	519.266	7604.85
*CESat-1 Separation	17 min 0.94 sec	511.052	7608.71
NIUSAT Separation	16 min 50.94 sec	510.853	7608.81
Cartosat-2 Series Satellite Separation	16 min 40.94 sec	510.656	7608.90
Fourth Stage Cut-off (Injection)	15 min 58.94 sec	509.854	7604.83
Fourth Stage Ignition	8 min 21.12 sec	430.405	5914.09
Third Stage Separation	8 min 11.22 sec	424.251	5923.04
Third Stage Ignition	4 min 22.92 sec	226.596	4040.56
Second Stage Separation	4 min 21.72 sec	225.378	4043.33
Payload Fairing Separation	2 min 38.96 sec	121.683	2456.24
Second Stage Ignition	1 min 50.46 sec	68.470	2157.42
First Stage Separation	1 min 50.26 sec	68.241	2158.26
Strap-on 5, 6 (Airlit) Separation	1 min 32.0 sec	47.254	1863.21
Strap-on 3, 4 (Groundlit) Separation	1 min 10.1 sec	26.973	1315.18
Strap-on 1, 2 (Groundlit) Separation	1 min 9.9 sec	26.816	1310.61
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.767	574.99
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.0238	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.0238	451.89
First Stage Ignition	0	0.0238	451.89

(* All other nano satellites are separating between 17 min 0.94 sec and 23 min 18.94 sec)

PSLV-C38 Typical Flight Profile

Placement of Base Shroud and Nozzle End Segment Module of PSLV-C38 core stage on the launch pedestal

Assembly of third and fourth stages of PSLV-C38 at Stage Preparation Facility

Primary Satellite

The Cartosat-2 Series Satellite is the primary satellite being carried by PSLV-C38. This remote sensing satellite is similar to the earlier five satellites of the Cartosat-2 series. After its injection into a 505 km polar Sun Synchronous Orbit by PSLV-C38, the satellite will be brought to operational configuration, following which it will begin providing regular remote sensing services using its Panchromatic and Multispectral cameras.

The imagery sent by the satellite will be useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, change detection to bring out geographical and manmade features and various other Land Information System (LIS) as well as Geographical Information System (GIS) applications.

Cartosat-2 Series Satellite undergoing solar panel deployment test

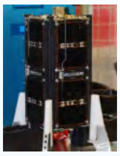
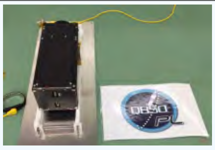
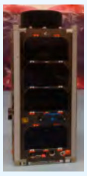
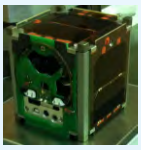
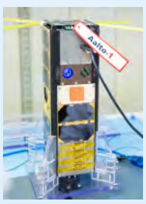
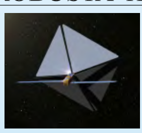
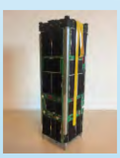
Salient features

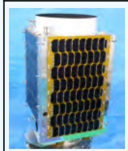
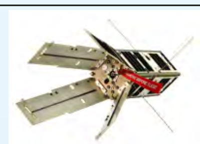
Satellite mass	712 Kg
Orbit type	Circular polar Sun Synchronous
Orbit height	505 km
Orbit inclination	97.44 degree
Orbit period	94.72 min
Local time of Equator crossing	9:30 am
Power	Solar arrays generating 986 Watts; Two Li-Ion batteries
Attitude control	Reaction wheels, Magnetic torquers and Hydrazine thrusters
Design life	5 years

PSLV-C38/CARTOSAT-2 SERIES SATELLITE

Co-passenger Satellites

International Customer Satellites (29 Nos.)

Nano Satellite	Country	Objective
 PEGASUS/AT03	Austria	Measuring the plasma temperature and density in the thermosphere
 QB50-BE06	Belgium	Atmospheric Ion/Neutral Particle Detection and Space Imaging
 InflateSail	Belgium	Demonstration of the effectiveness of drag deorbiting from LEO using inflatable boom and motor driven sail combination
 UCLSat	Belgium	To measure ions and neutrals in the thermosphere
 SUCHAI-1	Chile	To study the physics of LEO environment and its effects on electronic and systems
 VZLUSAT-1	Czech Republic	Atmospheric research
 Aalto-1	Finland	Technology demonstration of miniature Fabry-Perot spectral imager, small radiation monitor and satellite deorbiting with Plasma Brake
 ROBUSTA-1B	France	Scientific and educative
 QB50-DE04	Germany	DragSail deployment and fast de-orbiting for space debris removal demonstration
 URSAMAIOR	Italy	In-Orbit demonstration of reliable fail-safe computing architectures and a drag sail for deorbiting

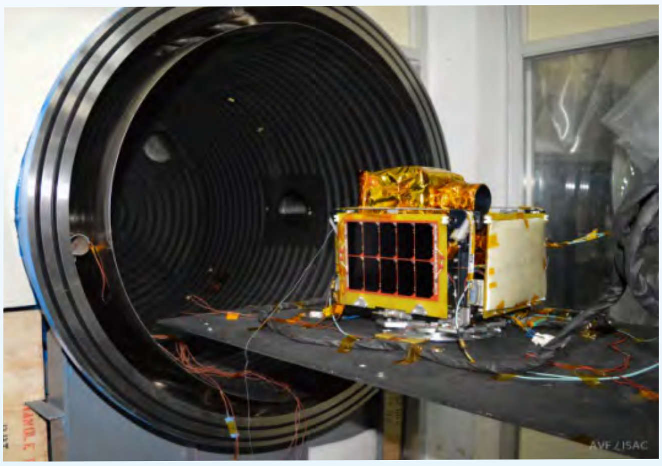
Nano Satellite	Country	Objective
 D-SAT	Italy	To demonstrate D-Orbit's decommissioning technology on-orbit
 Max Valier	Italy	Educational satellite with X-Ray telescope for universe mapping and maritime Automatic Identification System (AIS)
 CE-SAT1	Japan	Demonstration of remote sensing based on Canon group technology
 Venta-1	Latvia	Educational satellite for maritime Automatic Identification System (AIS), spherical 360° imaging system for vision based attitude determination and navigation experiments
 LituanicaSAT-2	Lithuania	Oxygen measurements Flux-Φ-Probe Experiment (FIPEX) and Ecologic chemical propulsion (EPSS) orbital demonstration
 skCUBE	Slovakia	Popularisation of science and technology, Technology verification
 3 Diamonds (3 Nos.)	United Kingdom	To provide voice, instant messaging, M2M and IoT services as a commercial demonstration for a full equatorial constellation
 CICERO-6	USA	Demonstration of GPS radio occultation sensor that allows the measurement of global weather patterns with high accuracy
 Tyvak-53b	USA	Technology demonstration for deorbiting the nano satellites
 LEMUR-2 (8 Nos.)	USA	Vessel tracking using Automatic Identification System (AIS) and weather measurement using GPS Radio Occultation

Indian University Satellite - NIUSAT

NIUSAT is an Indian University/Academic Institute satellite from Noorul Islam University in Tamil Nadu State. This 15 kg three axis stabilised satellite is built to provide multispectral imagery for agricultural crop monitoring and disaster management support applications.

A dedicated Mission Control Center with UHF/VHF antenna for Telemetry/Tele-command operations and S-Band antenna for Payload data reception has been established at the University.

NIUSAT in Clean Room



NIUSAT being Prepared for Thermal Vacuum Test

Salient features

Satellite mass	15 Kg
Overall Size	348 x 348 x 370 mm^3
Power	40 Watts
Battery	10 Ah, Li-Ion
Payload	RGB Camera
Resolution	25 Meters (from 500 Km altitude)
Image Size	50 Km x 50 Km

PSLV-C40

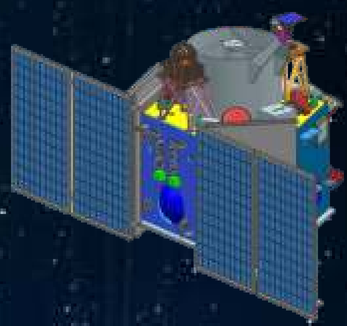
CARTOSAT-2 Series Satellite

Microsatellite

INS-1C

International co-passenger Satellites

Telesat Phase-1 LEO
POC-1
PICSAT
CANYVAL-X
CNUSAIL-1
KAUSAT-5
SIGMA
STEP CUBE LAB
CBNT-2
Flock-3P' (4 no.)
LEMUR (4 no.)
DemoSat-2
Micromas-2
Tyvak-61C
SpaceBEE (4 no.)
Fox-1D
Corvus BC3
Arkyd-6
CICERO-7



PSLV-C40 at the First Launch Pad

PSLV-C40

India's Polar Satellite Launch Vehicle, in its forty second flight (PSLV-C40), will launch the 710 kg Cartosat-2 Series Satellite for earth observation and 30 co-passenger satellites together weighing about 613 kg at lift-off.

The co-passenger satellites comprise one microsatellite and one nanosatellite from India as well as 3 microsatellites and 25 nanosatellites from six countries, viz., Canada, Finland, France, Republic of Korea, UK and USA. The total weight of all the 31 satellites carried onboard PSLV-C40 is about 1323 kg.

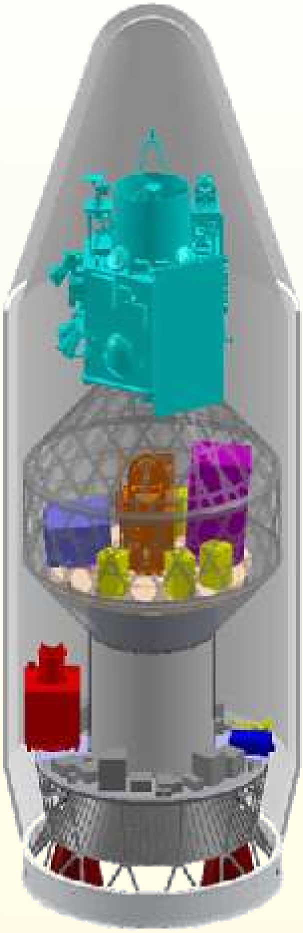
30 of 31 satellites carried by PSLV-C40 will be first launched into a 505 km polar Sun Synchronous Orbit (SSO) while Microsat built by ISRO will be placed in a 359 km polar SSO after bringing down the orbital height by twice restarting the PSLV-C40 fourth stage. PSLV-C40 will be launched from the First Launch Pad (FLP) of Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota.

The 28 International customer satellites are being launched as part of the commercial arrangements between Antrix Corporation Limited (Antrix), a Government of India company under Department of Space (DOS), the commercial arm of ISRO and the International customers.

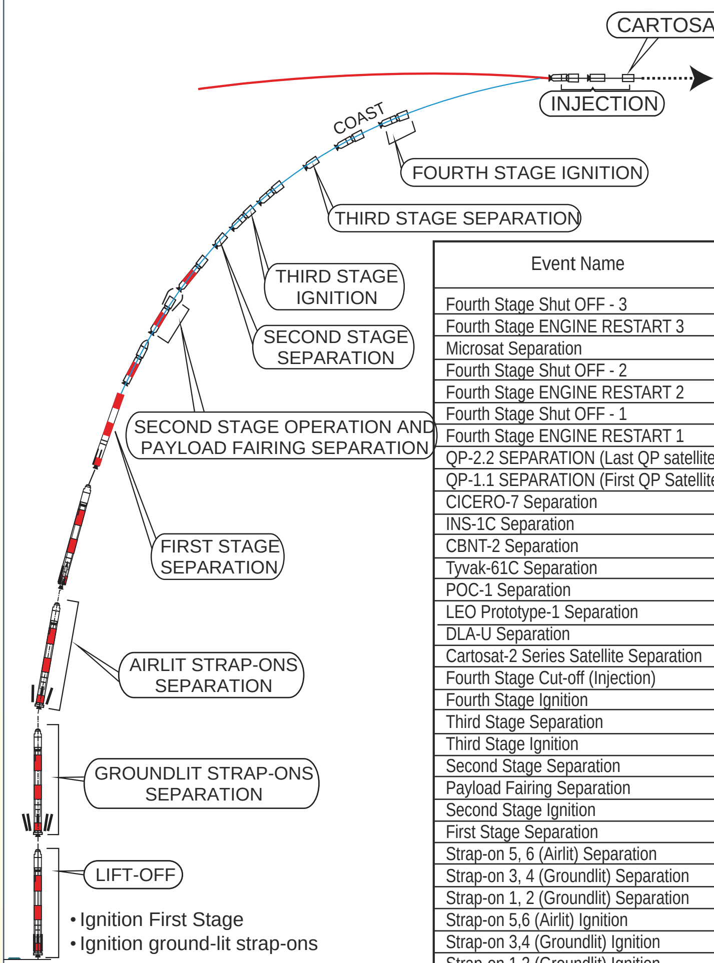
PSLV-C40 at a glance (lift-off Mass: 320 tonne Height: 44.4 m)

	Stage-1	Stage-2	Stage-3	Stage-4
Nomenclature	Core Stage PS1 + 6 Strap-on Motors	PS2	PS3	PS4
Propellant	Composite solid	Earth Storable Liquid	Composite solid	Earth Storable Liquid
Propellant Mass(T)	138.2 (Core), 6 x 12.2 (Strap-on)	42.0	7.6	2.5
Stage Dia (m)	2.8 (Core), 1 (Strap-on)	2.8	2.0	1.34
Stage Length (m)	20 (Core), 12 (Strap-on)	12.8	3.6	3.0

PSLV-C40/CARTOSAT-2 SERIES SATELLITE



Payload Accommodation details of PSLV-C40



Height: 505 km
Inclination: 97.47 deg

Event Name	Time after lift-off	Altitude (kilometre)	Velocity (metre per second)
Fourth Stage Shut OFF - 3	2 hr 21.62 sec	374.978	7681.12
Fourth Stage ENGINE RESTART 3	2 hr 8.02 sec	374.783	7688.08
Microsat Separation	1 hr 45 min 35.74 sec	359.584	7691.32
Fourth Stage Shut OFF - 2	1 hr 44 min 58.74 sec	359.367	7698.04
Fourth Stage ENGINE RESTART 2	1 hr 44 min 54.02 sec	359.352	7731.73
Fourth Stage Shut OFF - 1	58 min 18.24 sec	505.335	7578.23
Fourth Stage ENGINE RESTART 1	58 min 13.52 sec	505.328	7608.63
QP-2.2 SEPARATION (Last QP satellite)	23 min 56.8 sec	519.049	7605.20
QP-1.1 SEPARATION (First QP Satellite)	20 min 41.8 sec	514.696	7607.30
CICERO-7 Separation	19 min 46.8 sec	513.442	7607.92
INS-1C Separation	19 min 36.8 sec	513.216	7608.02
CBNT-2 Separation	19 min 26.8 sec	512.991	7608.13
Tyvak-61C Separation	19 min 16.8 sec	512.767	7608.24
POC-1 Separation	17 min 49.02 sec	510.846	7609.17
LEO Prototype-1 Separation	17 min 48.8 sec	510.841	7609.17
DLA-U Separation	17 min 33.8 sec	510.525	7609.32
Cartosat-2 Series Satellite Separation	17 min 18.8 sec	510.213	7609.48
Fourth Stage Cut-off (Injection)	16 min 36.8 sec	509.365	7605.49
Fourth Stage Ignition	8 min 21.72sec	440.605	5871.32
Third Stage Separation	8 min 11.72 sec	434.362	5880.39
Third Stage Ignition	4 min 22.54 sec	230.492	4060.74
Second Stage Separation	4 min 21.34 sec	229.224	4063.60
Payload Fairing Separation	2 min 31.72 sec	115.633	2423.45
Second Stage Ignition	1min 48.82 sec	67.831	2164.78
First Stage Separation	1min 48.62 sec	67.599	2165.63
Strap-on 5, 6 (Airlit) Separation	1 min 32.0 sec	48.223	1907.66
Strap-on 3, 4 (Groundlit) Separation	1 min 10.1 sec	27.473	1345.34
Strap-on 1, 2 (Groundlit) Separation	1 min 9.9 sec	27.313	1340.61
Strap-on 5,6 (Airlit) Ignition	25.0 sec	2.869	581.76
Strap-on 3,4 (Groundlit) Ignition	0.62 sec	0.0238	451.89
Strap-on 1,2 (Groundlit) Ignition	0.42 sec	0.0238	451.89
First Stage Ignition	0	0.0238	451.89

PSLV-C40 Typical Flight Profile

Hoisting of PSLV-C40 core stage nozzle end segment during vehicle integration

PSLV-C40 integrated upto fourth stage inside Mobile Service tower

Primary Satellite

The Cartosat-2 Series Satellite is the primary satellite being carried by PSLV-C40. This remote sensing satellite is similar to the earlier six satellites of the Cartosat-2 series and is intended to augment data services to the users. After its injection into a 505 km polar Sun Synchronous Orbit by PSLV-C40, the satellite will be brought to operational configuration, following which it will begin providing regular remote sensing services using its Panchromatic and Multispectral cameras.

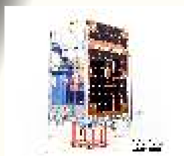
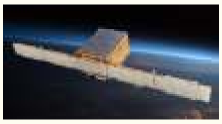
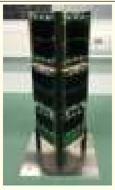
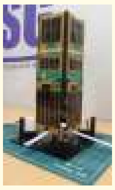
The imagery sent by the satellite will be useful for cartographic applications, urban and rural applications, coastal land use and regulation, utility management like road network monitoring, water distribution, creation of land use maps, change detection to bring out geographical and manmade features and various other Land Information System (LIS) as well as Geographical Information System (GIS) applications.

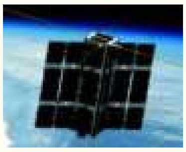
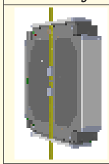
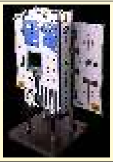
CARTOSAT-2 Series Satellite at clean room

Salient features

Satellite mass	710 Kg
Orbit type	Circular polar Sun Synchronous
Orbit height	505 km
Orbit inclination	97.47 degree
Orbit period	94.72 min
Local time of Equator crossing	9:30 am
Power	Solar arrays generating 986 Watts; Two Li-Ion batteries
Attitude control	Reaction wheels, Magnetic torquers and Hydrazine thrusters
Design life	5 years

PSLV-C40/CARTOSAT-2 SERIES SATELLITE
International co-passenger Satellites

Satellite	Country	Objective
 Telesat Phase-1 LEO	Canada	Ka-band communication satellite meant for demonstrating the capability of satellite and customer terminal for delivering low latency broadband experiences
 POC-1	Finland	SAR Payload Proof-of-Concept demonstration
 PICSAT	France	Measurement of exoplanetary transits
 CANYVAL-X	Republic of Korea	To demonstrate astronomy with virtual telescope
 CNUSAIL-1		To demonstrate solar sail technology
 KAUSAT-5		Infrared imaging of the Earth
 SIGMA		To demonstrate probing of space radiation
 STEP CUBE LAB		To demonstrate thruster, radiator and heat pipe technologies
 CBNT-2	UK	CBNT-2 is an Earth observation technology demonstration mission, to test and validate a high definition imagery and video system

Satellite	Country	Objective
 Flock-3P' (Four)	USA	Earth Observation
 LEMUR (Four)	USA	Automatic Identification System (AIS) for Vessel monitoring
 DemoSat-2	USA	UHF radio test
 Micromas-2	USA	Microwave radiometer test
 Tyvak-61C	USA	To catalog variability of luminous stars
 SpaceBEE (Four)	USA	2-way satellite communications and data relay
 Fox-1D	USA	Amateur radio communications
 Corvus BC3	USA	Multi-spectral remote sensing
 Arkyd-6	USA	Demonstration of core technology for use in asteroid exploration
 CICERO-7	USA	To measure global weather patterns with high accuracy using a GPS radio occultation sensor

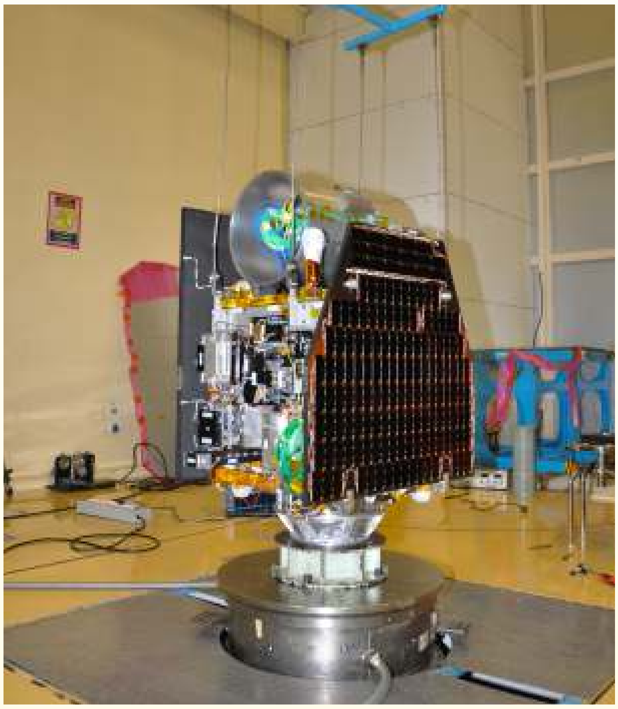
28 International Customer Satellites together weigh 470 kg.

PSLV- C40/CARTOSAT-2 SERIES SATELLITE

Indian co-passenger Satellites

Microsatellite

PSLV-C40 carries a Microsat built by ISRO as a co-passenger payload. Microsat is a small satellite in the 100 kg class that derives its heritage from IMS-1 bus. This is a technology demonstrator and the fore runner for future satellites of this series. The satellite bus is modular in design and can be fabricated and tested independently of payload.



Microsat during prelaunch testing

Indian Nano Satellite-1C (INS-1C)

Indian Nano Satellite-1C is another Indian co-passenger payload of PSLV-C40. It is the third satellite in the Indian Nanosatellite series. The first two satellites of this series were carried as co-passenger payloads by PSLV-C37 in February 2017. INS-1C will be carrying Miniature Multispectral Technology Demonstration (MMX-TD) Payload from Space Applications Centre (SAC). Data sent by this camera can be utilised for topographical mapping, vegetation monitoring, aerosol scattering studies and cloud studies.

Indian Nano Satellite (INS) is a versatile and modular Nano satellite bus system envisioned for future science and experimental payloads. With a capability to carry up to 3 kg of payload and a total satellite mass of 11 kg, it offers immense opportunities for future use. The INS system is developed as a co-passenger satellite to accompany bigger satellites on PSLV launch vehicle. Its primary objectives include providing a standard satellite bus for launch on demand services and providing opportunity to carry innovative payloads.

INS-1C with its panels in deployed condition

Major Specifications of INS-1C

Parameter	Specifications
Mass	11 kg
Overall Size	245 x 227 x 217 mm^3
Structure	Milled aluminium decks
Thermal control	Passive (OSR, MLI, Paints etcs.) & Battery Heaters
Mechanisms	Solar panels & Antenna deployment
Power	Solar Panels generating about 27W 11.2 Ah Lithium Ion battery
Attitude and Orbit Control System (AOCS)	Attitude sensors: Star Sensor, MEMS IMU, Micro Sun sensors, Digital Magnetometer Actuators: Four Reaction wheels, Magnetic Torquers
Control accuracy	<0.5 about each axis
TM and TC links	Telecommand: (VHF) Telemetry: (UHF), S - Band
Data Transmission and storage	One Mbps in S-band On-board Micro SD of 8 GB capacity
Mission life	6 months
Payload	MMX-TD

January 2018

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